TABLES OF

REMAINING VELOCITY, TIME OF FLIGHT, AND ENERGY OF VARIOUS PROJECTILES,

CALCULATED FROM THE RESULTS OF EXPERIMENTS MADE WITH THE BASHFORTH CHRONOGRAPH, 1865-1870:

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(*Continued from p.* 392, *Vol. VII.*)

DESCRIPTION AND USE OF GENERAL TABLES 22 AND 23.

SUPPOSE a body to have been projected with an initial velocity V, and when moving with a velocity v to be acted upon by a retarding force $2bv^3$, at which instant let t denote the time and s the space described. Then the cubic law of resistance gives rise to the following expressions for determining s and t corresponding to a given loss of velocity $V-v$, namely

$$2bs = \frac{1}{v} - \frac{1}{V},$$

$$\text{and } 4bt = \frac{1}{v^2} - \frac{1}{V^2}.$$

The retarding effect of the air on the motion of projectiles has been expressed under the form $2bv^3$; but as the resistance of the air varies only approximately as the cube of the velocity, the coefficient b must vary with v. The numerical values of $2000b\frac{w}{d^2}$ for spherical and for elongated ogival-headed shot have been determined experimentally, where w = weight of the shot in lbs. and d its diameter in inches.*

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* "Reports on Experiments made with the Bashforth Chronograph, 1865-70," pp. 114, 152.

Suppose that $2000b\frac{w}{d^2}=N$, the tabular number corresponding to the mean value of V and v.. Then the above equations take the form

$$s\frac{d^2}{w}=\frac{1000}{N}\left(\frac{1}{v}-\frac{1}{V}\right)\dots\dots(1)$$

$$\text{and } t\frac{d^2}{w}=\frac{1000}{2N}\left(\frac{1}{v^2}-\frac{1}{V^2}\right)\dots\dots(2)$$

Thus from the above equations we find that $s\frac{d^2}{w}$ and $t\frac{d^2}{w}$ are functions of V, v, and of N, which depends upon the *external form* but not on the weight or diameter of the projectile. Taking equation (2), suppose that V is the initial velocity, and that v_1, v_2, v_3, &c., are the velocities of the shot at times t_1, t_1+t_2, $t_1+t_2+t_3$, &c., we have

$$t_1\frac{d^2}{w}=\frac{1000}{2N_1}\left(\frac{1}{v_1^2}-\frac{1}{V^2}\right),$$

$$t_2\frac{d^2}{w}=\frac{1000}{2N_2}\left(\frac{1}{v_2^2}-\frac{1}{v_1^2}\right),$$

$$t_3\frac{d^2}{w}=\frac{1000}{2N_3}\left(\frac{1}{v_3^2}-\frac{1}{v_2^2}\right), \text{ \&c., \&c.}$$

In the calculation of the General Time Table for ogival-headed shot, $V=1700$ f.s., $v_1=1690$ f.s., $v_2=1680$ f.s., $v_3=1670$ f.s., &c., and N_1 corresponds to a velocity 1695 f.s., N_2 to 1685 f.s., N_3 to 1675 f.s., &c.

Thus a table was formed showing the times in which the projectile successively lost 10 feet in velocity. Afterwards the table was completed by interpolation.

(1) Suppose it was required to find by the help of the General Table in what time the velocity of a 700-lb. elongated shot would be reduced from 1344 to 1129 f.s. Here $d=11{\cdot}52$ inches and $\frac{d^2}{w}={\cdot}1896$. By Table **23** we find 1″·0806 corresponding to a velocity 1344 f.s., and 2″·1464 to a velocity 1129 f.s. Hence (time required) $\times\frac{d^2}{w}=2''{\cdot}1464-1''{\cdot}0806=1''{\cdot}0658$, which gives the required time $=1''{\cdot}0658\div{\cdot}1896=5''{\cdot}621$.

(2) Suppose that the initial velocity of a 250-lb. elongated shot was 1310 f.s., and that it was asked in what time its velocity would be reduced to 1022 f.s. Here $d=8{\cdot}92$ inches, and $\frac{d^2}{w}={\cdot}3183$, and the time required $=(3''{\cdot}0335-1''{\cdot}2163)\div{\cdot}3183=1''{\cdot}8172\div{\cdot}3183=5''{\cdot}709$.

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(3) Suppose it was asked how much the velocity of a 115-lb. elongated shot would be reduced from 1200 f.s. in $3''\cdot659$. Here $d=6\cdot92$ inches and $\frac{d^2}{w}=\cdot4164$. We must first calculate the value of $t\frac{d^2}{w}=3''\cdot659\times\cdot4164=1''\cdot5236$. Hence the required velocity will be opposite the time $1''\cdot5236$ added to $1''\cdot7309$, which belongs to the initial velocity 1200 f.s.; that is, opposite $3''\cdot2545$, which is 1004 f.s. Hence in $3''\cdot659$ the velocity of a 115-lb. shot would be reduced from 1200 to 1004 f.s.

The General Time Table for spherical shot is used in precisely the same manner to find either the time in which a given loss of velocity takes place, or the loss of velocity which takes place in a given time. The General Tables **20** and **21** connecting space and velocity were calculated from formula (1) in precisely the same manner as those connecting velocity and time have been calculated from formula (2); but the form of the equation connecting the space and time is one which does not admit of the formation of a general table to shew the direct dependence of one on the other. But suppose it was desired to know in what time a 115-lb. elongated shot would describe 4000 ft., starting with an initial velocity of 1200 f.s. First find what would be the velocity v when the shot had described 4000 ft. by the General Table **21**, and then find by the help of Table **23** in what time the velocity would fall from 1200 f.s. to v. These general tables may perhaps admit of being used to calculate the trajectories of shot fired with high initial velocities and low angles of elevation.

December 20, 1871.

22 *A General Table for facilitating the Calculation of the Time corresponding to a given loss of Velocity of any Spherical Shot.*

v.	. 9	8	7	6	5	4	3	2	1	0
f.s.	″	″	″	″	″	″	″	″	″	″
189	0·0013	·0027	·0040	·0054	·0067	·0081	·0094	·0108	·0121	·0135
188	·0148	·0162	·0175	·0189	·0203	·0216	·0230	·0244	·0257	·0271
187	·0285	·0298	·0312	·0326	·0340	·0353	·0367	·0381	·0395	·0409
186	0·0423	·0437	·0451	·0465	·0479	·0493	·0507	·0521	·0535	·0549
185	·0563	·0577	·0591	·0605	·0619	·0633	·0647	·0662	·0676	·0690
184	·0704	·0718	·0733	·0747	·0761	·0775	·0789	·0803	·0818	·0832
183	0·0846	·0861	·0875	·0889	·0904	·0918	·0933	·0948	·0962	·0977
182	·0992	·1006	·1021	·1035	·1050	·1065	·1079	·1094	·1108	·1123
181	·1138	·1152	·1167	·1182	·1196	·1211	·1226	·1240	·1255	·1270
180	0·1285	·1300	·1314	·1329	·1344	·1359	·1374	·1389	·1404	·1419
179	0·1434	·1449	·1464	·1479	·1494	·1509	·1524	·1540	·1555	·1570
178	·1585	·1600	·1616	·1631	·1646	·1662	·1677	·1692	·1708	·1723
177	·1738	·1754	·1769	·1784	·1800	·1815	·1831	·1846	·1861	·1877
176	0·1892	·1908	·1924	·1939	·1955	·1971	·1987	·2002	·2018	·2034
175	·2050	·2065	·2081	·2097	·2113	·2129	·2145	·2160	·2176	·2192
174	·2208	·2223	·2239	·2255	·2271	·2287	·2303	·2319	·2335	·2351
173	0·2367	·2383	·2400	·2416	·2432	·2448	·2465	·2481	·2497	·2513
172	·2530	·2546	·2562	·2579	·2595	·2611	·2628	·2644	·2660	·2677
171	·2693	·2710	·2726	·2742	·2759	·2776	·2792	·2809	·2825	·2842
170	0·2859	·2875	·2892	·2909	·2926	·2942	·2959	·2976	·2993	·3010
169	0·3026	·3043	·3060	·3077	·3094	·3111	·3128	·3145	·3162	·3179
168	·3196	·3213	·3231	·3248	·3265	·3282	·3300	·3317	·3334	·3351
167	·3369	·3386	·3403	·3421	·3438	·3456	·3473	·3491	·3508	·3525
166	0·3543	·3560	·3578	·3595	·3613	·3631	·3648	·3666	·3684	·3701
165	·3719	·3737	·3754	·3772	·3790	·3808	·3825	·3843	·3861	·3879
164	·3897	·3915	·3933	·3951	·3969	·3987	·4005	·4023	·4041	·4059
163	0·4077	·4095	·4113	·4131	·4150	·4168	·4186	·4205	·4223	·4242
162	·4261	·4279	·4297	·4316	·4334	·4353	·4371	·4390	·4408	·4427
161	·4446	·4464	·4483	·4502	·4521	·4539	·4558	·4577	·4596	·4615
160	0·4634	·4653	·4672	·4691	·4710	·4729	·4748	·4767	·4786	·4805
159	0·4824	·4843	·4863	·4882	·4901	·4921	·4940	·4959	·4979	·4998
158	·5017	·5037	·5056	·5075	·5095	·5114	·5134	·5154	·5173	·5193
157	·5213	·5233	·5252	·5272	·5292	·5312	·5331	·5351	·5371	·5391
156	0·5411	·5431	·5451	·5472	·5492	·5512	·5532	·5553	·5573	·5593
155	·5614	·5634	·5654	·5675	·5695	·5715	·5736	·5756	·5776	·5797
154	·5817	·5838	·5859	·5879	·5900	·5921	·5941	·5962	·5983	·6003
153	0·6024	·6045	·6066	·6087	·6108	·6129	·6150	·6171	·6192	·6213
152	·6234	·6255	·6277	·6298	·6319	·6341	·6362	·6383	·6405	·6426
151	·6448	·6469	·6491	·6512	·6534	·6556	·6577	·6599	·6620	·6642
150	0·6664	·6686	·6707	·6729	·6751	·6773	·6795	·6817	·6839	·6861
149	0·6883	·6905	·6928	·6950	·6972	·6995	·7017	·7039	·7062	·7084
148	·7107	·7129	·7152	·7174	·7197	·7219	·7242	·7265	·7287	·7310
147	·7333	·7355	·7378	·7401	·7424	·7447	·7470	·7493	·7516	·7539
146	0·7562	·7585	·7608	·7632	·7655	·7678	·7702	·7725	·7748	·7772
145	·7796	·7819	·7843	·7867	·7890	·7914	·7937	·7961	·7984	·8008
144	·8032	·8056	·8080	·8104	·8128	·8152	·8176	·8200	·8224	·8248
143	0·8273	·8297	·8321	·8346	·8370	·8394	·8419	·8443	·8468	·8492
142	·8517	·8542	·8566	·8591	·8616	·8641	·8665	·8690	·8715	·8740
141	·8765	·8790	·8815	·8841	·8866	·8891	·8916	·8942	·8967	·8992
140	0·9018	·9043	·9069	·9094	·9120	·9146	·9171	·9197	·9222	·9248

Table **22**—*continued.*

v.	9	8	7	6	5	4	3	2	1	0
f.s.	″		″	″	″	′	′	″	″	″
139	0·9274	·9300	·9326	·9352	·9378	·9404	·9430	·9456	·9482	·9508
138	·9535	·9561	·9587	·9614	·9640	·9667	·9693	·9720	·9746	·9773
137	·9800	·9826	·9853	·9880	·9907	·9933	·9960	·9987	**·0014**	**·0041**
136	1·0068	·0095	·0122	·0149	·0177	·0204	·0231	·0259	·0286	·0315
135	·0342	·0370	·0397	·0425	·0453	·0481	·0509	·0537	·0565	·0593
134	·0621	·0649	·0677	·0705	·0734	·0762	·0791	·0819	·0848	·0877
133	1·0905	·0934	·0963	·0991	·1020	·1049	·1078	·1107	·1136	·1165
132	·1195	·1224	·1253	·1283	·1312	·1342	·1371	·1401	·1430	·1460
131	·1490	·1519	·1549	·1579	·1609	·1639	·1669	·1699	·1729	·1759
130	1·1790	·1820	·1850	·1881	·1911	·1942	·1972	·2003	·2033	·2064
129	1·2095	·2126	·2157	·2188	·2219	·2250	·2281	·2312	·2344	·2375
128	·2407	·2438	·2470	·2502	·2533	·2565	·2597	·2628	·2660	·2692
127	·2724	·2756	·2788	·2821	·2853	·2885	·2918	·2950	·2982	·3015
126	1·3048	·3080	·3113	·3146	·3179	·3212	·3245	·3278	·3311	·3344
125	·3378	·3411	·3444	·3478	·3511	·3545	·3578	·3612	·3645	·3679
124	·3713	·3747	·3781	·3815	·3849	·3884	·3918	·3952	·3987	·4021
123	1·4056	·4090	·4125	·4160	·4195	·4230	·4265	·4300	·4336	·4371
122	·4407	·4442	·4478	·4513	·4549	·4585	·4620	·4656	·4692	·4728
121	·4764	·4800	·4836	·4873	·4909	·4945	·4982	·5018	·5055	·5092
120	1·5129	·5166	·5203	·5240	·5277	·5315	·5352	·5390	·5428	·5465
119	1·5503	·5541	·5579	·5617	·5655	·5694	·5732	·5770	·5809	·5847
118	·5886	·5925	·5963	·6002	·6041	·6080	·6120	·6159	·6198	·6238
117	·6278	·6317	·6357	·6397	·6437	·6478	·6518	·6558	·6599	·6639
116	1·6680	·6721	·6762	·6803	·6844	·6886	·6927	·6968	·7010	·7051
115	·7093	·7135	·7177	·7219	·7261	·7304	·7346	·7388	·7431	·7473
114	·7516	·7559	·7602	·7646	·7689	·7732	·7776	·7819	·7863	·7907
113	1·7951	·7996	·8040	·8084	·8129	·8174	·8219	·8264	·8309	·8354
112	·8400	·8445	·8491	·8536	·8582	·8628	·8674	·8720	·8767	·8813
111	·8860	·8907	·8954	·9001	·9048	·9096	·9143	·9191	·9238	·9286
110	1·9334	·9383	·9431	·9479	·9528	·9577	·9627	·9676	·9726	·9775
109	1·9825	·9875	·9925	·9975	**·0025**	**·0076**	**·0126**	**·0177**	**·0228**	**·0279**
108	2·0331	·0382	·0434	·0486	·0538	·0591	·0643	·0696	·0748	·0801
107	·0854	·0908	·0961	·1015	·1069	·1124	·1178	·1232	·1287	·1341
106	2·1396	·1452	·1507	·1562	·1618	·1674	·1731	·1787	·1844	·1901
105	·1958	·2016	·2073	·2131	·2189	·2247	·2306	·2364	·2422	·2481
104	·2540	·2600	·2659	·2719	·2779	·2840	·2900	·2961	·3022	·3083
103	2·3145	·3207	·3269	·3331	·3393	·3456	·3519	·3582	·3645	·3708
102	·3772	·3836	·3900	·3965	·4029	·4094	·4160	·4225	·4290	·4356
101	·4422	·4489	·4555	·4622	·4689	·4757	·4824	·4892	·4960	·5028
100	2·5096	·5165	·5234	·5303	·5373	·5443	·5513	·5583	·5654	·5724
99	2·5795	·5867	·5938	·6010	·6082	·6155	·6227	·6300	·6373	·6446
98	·6519	·6593	·6667	·6741	·6816	·6891	·6966	·7041	·7117	·7192
97	·7268	·7344	·7421	·7498	·7575	·7653	·7731	·7809	·7887	·7965
96	2·8044	·8123	·8202	·8282	·8361	·8441	·8521	·8602	·8683	·8764
95	·8846	·8928	·9010	·9092	·9174	·9257	·9340	·9423	·9506	·9590
94	·9674	·9758	·9843	·9928	**·0013**	**·0099**	**·0185**	**·0271**	**·0357**	**·0444**
93	3·0531	·0618	·0706	·0794	·0882	·0970	·1059	·1148	·1237	·1327
92	·1417	·1508	·1598	·1689	·1780	·1871	·1963	·2055	·2147	·2240
91	·2333	·2426	·2520	·2614	·2708	·2803	·2898	·2993	·3088	·3184
90	3·3280	·3377	·3474	·3571	·3668	·3766	·3864	·3962	·4060	·4159

23 *A General Table for facilitating the Calculation of the Time corresponding to a given loss of Velocity of any Elongated Shot (Ogival Head).*

v.	9	8	7	6	5	4	3	2	1	0
f.s.	″	″	″	″	″	″	″	″	″	″
169	0·0024	·0049	·0073	·0098	·0122	·0146	·0171	·0195	·0220	·0244
168	·0269	·0294	·0318	·0343	·0368	·0393	·0418	·0443	·0468	·0493
167	·0518	·0543	·0569	·0594	·0619	·0644	·0669	·0695	·0720	·0745
166	0·0770	·0795	·0821	·0846	·0872	·0897	·0923	·0949	·0974	·1000
165	·1026	·1051	·1077	·1103	·1129	·1155	·1181	·1207	·1233	·1259
164	·1285	·1311	·1338	·1364	·1390	·1416	·1442	·1469	·1495	·1521
163	0·1548	·1574	·1600	·1627	·1653	·1680	·1706	·1733	·1759	·1786
162	·1813	·1839	·1866	·1893	·1920	·1947	·1973	·2000	·2027	·2054
161	·2081	·2108	·2135	·2162	·2189	·2216	·2243	·2270	·2297	·2324
160	0·2351	·2378	·2406	·2433	·2460	·2488	·2515	·2542	·2570	·2597
159	0·2625	·2652	·2680	·2707	·2735	·2763	·2790	·2818	·2845	·2873
158	·2901	·2928	·2956	·2984	·3012	·3039	·3067	·3095	·3123	·3151
157	·3179	·3207	·3236	·3264	·3292	·3320	·3349	·3377	·3405	·3433
156	0·3462	·3490	·3518	·3547	·3575	·3603	·3632	·3660	·3688	·3717
155	·3745	·3774	·3803	·3831	·3860	·3889	·3918	·3946	·3975	·4004
154	·4033	·4062	·4091	·4120	·4149	·4178	·4207	·4236	·4265	·4294
153	0·4323	·4353	·4382	·4411	·4440	·4470	·4499	·4528	·4558	·4587
152	·4617	·4646	·4676	·4705	·4735	·4765	·4795	·4824	·4854	·4884
151	·4914	·4944	·4974	·5004	·5034	·5064	·5094	·5124	·5154	·5184
150	0·5214	·5244	·5275	·5305	·5335	·5366	·5396	·5426	·5457	·5487
149	0·5518	·5548	·5579	·5609	·5640	·5671	·5701	·5732	·5763	·5794
148	·5825	·5856	·5887	·5918	·5949	·5980	·6011	·6042	·6073	·6104
147	·6136	·6167	·6198	·6230	·6261	·6293	·6324	·6356	·6387	·6419
146	0·6451	·6483	·6514	·6546	·6578	·6610	·6642	·6674	·6706	·6738
145	·6770	·6802	·6834	·6867	·6899	·6931	·6963	·6996	·7028	·7060
144	·7093	·7125	·7158	·7191	·7223	·7256	·7289	·7322	·7355	·7388
143	0·7421	·7454	·7488	·7521	·7554	·7587	·7620	·7654	·7687	·7720
142	·7754	·7787	·7821	·7854	·7888	·7922	·7956	·7989	·8023	·8057
141	·8091	·8125	·8159	·8193	·8227	·8261	·8296	·8330	·8364	·8399
140	0·8434	·8468	·8503	·8538	·8572	·8607	·8642	·8677	·8712	·8747
139	0·8782	·8818	·8853	·8888	·8923	·8959	·8994	·9029	·9065	·9100
138	·9136	·9172	·9207	·9243	·9279	·9315	·9351	·9387	·9423	·9459
137	·9496	·9532	·9568	·9605	·9641	·9678	·9714	·9751	·9787	·9824
136	0·9861	·9898	·9935	·9972	**·0009**	**·0047**	**·0084**	**·0121**	**·0159**	**·0196**
135	1·0234	·0272	·0309	·0347	·0385	·0423	·0461	·0499	·0537	·0575
134	·0614	·0652	·0690	·0729	·0767	·0806	·0844	·0883	·0922	·0960
133	1·0999	·1038	·1077	·1116	·1156	·1195	·1234	·1274	·1313	·1353
132	·1393	·1432	·1472	·1512	·1552	·1592	·1633	·1673	·1713	·1754
131	·1794	·1835	·1876	·1916	·1957	·1998	·2039	·2080	·2122	·2163
130	1·2204	·2246	·2287	·2329	·2370	·2412	·2454	·2496	·2538	·2580
129	1·2622	·2665	·2707	·2749	·2792	·2835	·2878	·2921	·2964	·3007
128	·3050	·3093	·3137	·3180	·3223	·3267	·3310	·3354	·3498	·3442
127	·3486	·3530	·3574	·3619	·3663	·3708	·3752	·3797	·3842	·3887
126	1·3932	·3977	·4022	·4068	·4113	·4158	·4204	·4250	·4296	·4342
125	·4388	·4435	·4481	·4527	·4574	·4620	·4667	·4714	·4761	·4808
124	·4855	·4903	·4950	·4997	·5045	·5093	·5141	·5189	·5237	·5285
123	1·5334	·5382	·5431	·5479	·5528	·5577	·5626	·5675	·5724	·5773
122	·5823	·5872	·5922	·5971	·6021	·6071	·6121	·6172	·6222	·6272
121	·6323	·6373	·6424	·6475	·6526	·6578	·6629	·6681	·6732	·6784
120	1·6836	·6888	·6940	·6992	·7045	·7098	·7150	·7203	·7256	·7309

Table **23**—*continued.*

v.	9	8	7	6	5	4	3	2	1	0
f.s.	"	"	"	"	"	"	"	"	"	"
119	1·7362	·7416	·7469	·7523	·7576	·7630	·7684	·7738	·7792	·7847
118	·7901	·7956	·8011	·8066	·8121	·8176	·8232	·8287	·8343	·8399
117	·8455	·8512	·8568	·8625	·8681	·8738	·8795	·8852	·8909	·8966
116	1·9024	·9081	·9139	·9197	·9255	·9314	·9372	·9431	·9489	·9548
115	·9607	·9667	·9726	·9785	·9845	·9905	·9966	**·0026**	**·0087**	**·0147**
114	2·0208	·0269	·0330	·0392	·0453	·0515	·0577	·0639	·0702	·0764
113	2·0827	·0890	·0953	·1016	·1079	·1143	·1207	·1271	·1335	·1399
112	·1464	·1528	·1593	·1658	·1723	·1789	·1855	·1921	·1987	·2053
111	·2120	·2187	·2254	·2321	·2388	·2456	·2524	·2592	·2661	·2729
110	2·2798	·2867	·2936	·3005	·3074	·3144	·3214	·3285	·3355	·3426
109	2·3497	·3568	·3640	·3711	·3783	·3855	·3928	·4001	·4074	·4147
108	·4221	·4295	·4369	·4443	·4518	·4593	·4669	·4745	·4821	·4898
107	·4975	·5052	·5130	·5208	·5287	·5366	·5446	·5526	·5606	·5687
106	2·5768	·5850	·5932	·6015	·6098	·6182	·6266	·6351	·6437	·6523
105	·6610	·6697	·6785	·6874	·6963	·7053	·7144	·7236	·7328	·7420
104	·7514	·7608	·7703	·7798	·7894	·7991	·8089	·8188	·8288	·8388
103	2·8489	·8591	·8694	·8798	·8902	·9007	·9113	·9220	·9328	·9436
102	·9546	·9656	·9767	·9879	·9992	**·0106**	**·0220**	**·0335**	**·0450**	**·0567**
101	3·0685	·0803	·0922	·1042	·1163	·1284	·1406	·1529	·1653	·1778
100	3·1904	·2030	·2157	·2285	·2414	·2544	·2674	·2805	·2937	·3070
99	3·3204	·3339	·3474	·3610	·3747	·3885	·4024	·4163	·4303	·4444
98	·4586	·4729	·4873	·5017	·5162	·5308	·5455	·5602	·5750	·5899
97	·6049	·6200	·6352	·6504	·6657	·6811	·6966	·7121	·7277	·7434
96	3·7592	·7751	·7910	·8070	·8231	·8393	·8555	·8718	·8882	·9047
95	·9213	·9379	·9546	·9714	·9883	**·0052**	**·0222**	**·0393**	**·0565**	**·0738**
94	4·0911	·1085	·1260	·1436	·1612	·1790	·1968	·2147	·2326	·2506
93	4·2688	·2870	·3053	·3236	·3420	·3605	·3791	·3978	·4165	·4353
92	·4542	·4732	·4923	·5114	·5306	·5499	·5693	·5888	·6083	·6279
91	·6476	·6674	·6873	·7072	·7272	·7473	·7675	·7878	·8082	·8286
90	4·8491	·8697	·8904	·9112	·9321	·9531	·9741	·9952	**·0163**	**·0375**
89	5·0589	·0803	·1018	·1233	·1449	·1666	·1884	·2102	·2321	·2541
88	·2762	·2983	·3205	·3428	·3651	·3875	·4100	·4326	·4553	·4781
87	·5009	·5238	·5468	·5699	·5930	·6162	·6395	·6629	·6864	·7099
86	5·7335	·7572	·7810	·8049	·8289	·8529	·8770	·9012	·9255	·9499
85	·9744	·9990	**·0236**	**·0482**	**·0730**	**·0979**	**·1229**	**·1480**	**·1731**	**·1983**
84	6·2236	·2491	·2746	·3002	·3259	·3517	·3776	·4036	·4296	·4557
83	6·4819	·5083	·5347	·5612	·5878	·6146	·6414	·6683	·6953	·7224
82	·7496	·7769	·8043	·8318	·8594	·8871	·9150	·9429	·9709	·9990
81	7·0272	·0556	·0840	·1125	·1411	·1698	·1986	·2276	·2567	·2859
80	7·3152	·3446	·3741	·4036	·4333	·4631	·4931	·5231	·5532	·5835
79	7·6139	·6445	·6751	·7058	·7366	·7676	·7987	·8299	·8612	·8926
78	·9241	·9558	·9876	**·0195**	**·0515**	**·0837**	**·1160**	**·1484**	**·1809**	**·2136**
77	8·2464	·2793	·3123	·3455	·3788	·4122	·4458	·4795	·5133	·5472
76	8·5813	·6155	·6498	·6843	·7189	·7537	·7886	·8236	·8588	·8941
75	·9296	·9652	**·0009**	**·0368**	**·0728**	**·1090**	**·1453**	**·1817**	**·2183**	**·2550**
74	9·2919	·3289	·3661	·4034	·4408	·4784	·5162	·5541	·5922	·6305
73	9·6689	·7075	·7462	·7851	·8241	·8632	·9025	·9420	·9816	**·0216**
72	10·0616	·1018	·1421	·1826	·2232	·2639	·3049	·3461	·3875	·4291
71	·4708	·5127	·5548	·5970	·6394	·6819	·7246	·7675	·8107	·8540
70	10·8975	·9412	·9850	**·0290**	**·0732**	**·1176**	**·1622**	**·2070**	**·2520**	**·2972**

NOTES EXTRACTED FROM SOME GERMAN PAMPHLETS*

ON THE

EMPLOYMENT OF ARTILLERY IN THE FIELD.

BY

CAPTAIN W. G. BRANCKER, R.A.

Ranges.

Since infantry fire may now be considered as effective at 800 yds. and deadly at 300 yds., to bring guns to within case shot range of unshaken troops, more especially on ground admitting of cover, is to lead them to certain destruction; while firing at ranges from 4000 to 5000 yds. may be considered a waste of ammunition to be encouraged in an enemy but avoided on one's own part. It may then be laid down that artillery ought to avoid engaging troops at distances under 800 or over 3000 yds. when acting on the offensive, and that case shot is useful mainly for the defensive; though on rare occasions, when an enemy has become utterly demoralised by a fire at the longer range, victory may be completed by allowing the guns to accompany the assaulting columns.

Duties in the field.

The duties of artillery in the field are:—

1. To begin the action.
2. To hold an enemy in check, and thus gain time for the other arms to deploy.
3. To prepare for the attack of the other arms.
4. To withdraw an enemy's fire from them.
5. To aid the pursuit.
6. To cover a retreat.

The officer commanding artillery.

To enable artillery to carry out the above duties, it is necessary that its commander should be well acquainted with the intentions of the officer commanding the troops to which it may be attached; but this he cannot possibly be unless he is close to him. It may therefore be laid down that the place of the officer commanding the artillery is near to the commanding officer, so long as the troops are not engaged, but that when the batteries have once opened fire, the correcting of ranges, the keeping up of a sufficient supply of ammunition, the choice of the objects to be aimed at, will require his

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* "Ideen über die Verwendung der Feld-Artillerie," by Kraft Prinz zu Hohenlohe-Ingelfingen. Taubert's "Gebrauch der Feld-Artillerie." Perzonius, "Tactic."

attention, and his place will be with the guns, returning to the commanding officer of troops when they cease firing.

Attaching single batteries to brigades.

The attaching of single batteries to brigades is to be avoided, for the following reasons:—

1. The captain, as above stated, will have to be withdrawn from it to attend on the officer commanding the brigade.
2. Two batteries together have the advantage of one being able to correct its range by the other.
3. The massing of artillery is facilitated by keeping two or more batteries always together.

Artillery attached to a division. Detachments, when necessary. Detaching divisions.

Hence it follows that the artillery attached to a division ought to be kept together under one commander. Of course divisions acting independently will require some artillery with their advance guards. Guns must also be attached to brigades acting alone, whether of cavalry or infantry. But if the detaching of a single battery is to be deprecated, much more so is that of a division of a battery; when rendered absolutely necessary, as it may be from local causes, such as for the purpose of knocking down a barricade, let the division return to its battery immediately on completion of such special duty.

Rules for the Application of Artillery in the Field.

Application of artillery.

The exigencies of battle must be our guide in laying down these rules; for what is ordered in times of peace and practised on field days is attempted in battle, and therefore rules, except they provide for such exigencies, are utterly worthless.

Orders of battle.

Four orders of battle exist:—

1. Offensive.
2. Defensive.
3. The pursuit.
4. The retreat (deliberately made).

Two more orders might be included—the reconnaissance and the hurried or forced retreat; but neither can be conducted according to fixed rules—the first changing from the offensive to the defensive, and back again, while laying down rules for the latter would be about the same as laying them down for a thatcher in the act of falling from the roof he has been repairing.

Offensive battle by a single division.

The offensive battle may be said to commence somewhat thus:—The advance guard of the division comes upon the enemy; its foremost infantry or cavalry engage him; it becomes clear, from the position occupied and the nature of the defence he offers, that it is his intention to remain on the defensive. The artillery attached to the advance guard is at once brought up into carefully selected positions, and with its fire occupies the enemy, while

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dispositions are made with the other arms for attack. Suppose first, an unaided attack is determined on. The commander of the artillery being informed of this decision, as well as of the point selected for the attack, the batteries advance to the shorter ranges, try to dismount the enemy's guns and shatter his troops wherever visible, and thus prepare for the assault of the other arms.

Advance guard attacking unaided.

Suppose next, that either before the advance guard engages or while it is engaged, the enemy is found too strong for it to cope with single-handed. The commander of the division, by this time on the field, will have to make the further disposition, and he will find himself forced at once to bring up more artillery to strengthen that of the advance guard already engaged, in order to keep his more powerful enemy in check and gain time for the deployment of his infantry—a step the more necessary should the advance guard have become already seriously engaged, to enable it to hold out without exposing itself to a serious check before the larger masses can come up.

Advance guard keeping the enemy in check until the division comes up.

Attack of division similar to that of advance guard.

The attack of the division commences as that of the advance guard, by bringing the artillery to shorter ranges against that part of the enemy's position to be attacked.

Attack by a whole corps.

An attack is made by a whole corps in a similar manner to that laid down for the division and the brigade; there is, however, the modification that its advance guard is preceded by a vanguard of its own, accompanied by artillery, and standing in the same relation to it as the advance guard itself does to the corps. In the case of the corps, the reserve artillery is brought up to aid that of the advance guard in covering the deployment as well as in preparing for the attack of the other arms, while each division retains its own artillery for local protection. Should, however, either the nature of the ground or the order of battle render it desirable to attack at a different place to that at which the advance guard is engaged, its artillery may be retained for local purposes, while that of the divisions is massed with reserve artillery on the decisive point.

Attack.

The actual attack is carried out with columns of infantry formed under cover of this fire, which advance against the enemy as soon as he appears sufficiently shaken, the artillery fire being directed upon his infantry as long as it is possible to do so without endangering the attacking columns, and then diverted on to his artillery and such of his reserves as may be within range. Cases may occur where the advancing columns will totally mask their own artillery, forcing it to cease firing. Let it then remain prepared either to open fire on columns of the enemy who may threaten a flank movement, to advance into the position should it be taken, or to cover a retreat should such become necessary.

Exposed flank.

In an engagement conducted as above, the artillery coming into action on the flank of the advance guard will itself expose one flank, which will want protecting at first, but will soon be covered by the infantry deploying on both sides of it, as they almost invariably do, the only exception being when the ground suitable for

infantry tactics lies wholly on one flank of the artillery. This exceptional case demands a special protection for the exposed flank of the guns.

Pursuit. Should an attack succeed, and our infantry possess themselves of the enemy's position, this must at once be secured by advancing all the available guns into it, as well for the purpose of supporting our own infantry as to create confusion in the ranks of the retiring enemy, while the cavalry and horse artillery endeavour to check every attempt at renewed resistance on his part. Should the enemy make a stand in a new position, this must again be attacked, and thus a new offensive battle may develop itself. Obstacles such as rivers, though checking the advance of infantry and cavalry, afford a favourable opportunity for massing as many guns as are available, and harassing the retiring columns at long ranges.

Defensive battles. For a defensive battle, batteries having had their positions assigned to them previous to its commencement, a few only being kept in hand for massing on threatened points, the following rules may be laid down for the artillery :—

1. Disclose the entire strength as late as possible to the enemy.
2. Do not commence firing too soon.
3. Endeavour to destroy the enemy's artillery as it comes up, and before he has an equal number of guns to your own in action.
4. Remain in action until the latest moment.
5. By combining your case shot with infantry's fire, endeavour to gain for them a superiority to the last.

Retreat or rear guard fights. A part of the artillery being combined with the infantry or cavalry immediately concerned in covering the retreat, its mass ought to be sent back into the next good position in rear, there to form a fresh rallying point for the other troops, and by a well directed fire either to put a stop to the enemy's pursuit, or failing this at any rate to check it, and by forcing him to deploy afresh to gain time.

Horse artillery with cavalry. Seeing that cavalry are helpless on the defensive, and that they are kept out of fire until actually required to attack, it follows that horse artillery, when combined with this arm, acts on the offensive only, and that the time for its action is short, being limited to that required by the cavalry for coming up, deploying, and making the other necessary dispositions. As soon, therefore, as a cavalry attack is decided on, the horse artillery ought to gallop up to within from 1500 to 1000 yds. distance from the enemy, and direct their fire exclusively on the object to be attacked as long as they can do so without danger to the advancing cavalry, diverting it on to the enemy's artillery when this is no longer practicable. It may happen that the guns become for a time entirely masked by the advancing cavalry. Then arises the question: Is horse artillery, armed with rifled guns, as heretofore to gallop on in advance of the cavalry to within case shot range of the enemy, or is it to remain stationary? If the former course is pursued, such advance must be made either immediately the guns are thus masked—in which case it arrives too late, or at most in time to fire one round of case shot—

or else the artillery must advance before its cavalry arrives on the same line with it—must, in fact, forego the opportunity of firing several more rounds of shell from its old position deliberately, at well proved ranges, for the chance of being able hastily to pour one round of case from its light guns. We are of opinion that the horse artillery had better remain stationary under such circumstances, directing its fire on the enemy's artillery, on his reserves, and on any troops threatening a flank attack on our cavalry—a refuge for our cavalry if beaten back, and a check on any attempt of the enemy to pursue. It is only against infantry so thoroughly demoralised as to make every venture allowable, that the horse artillery should advance along with the cavalry to case shot ranges.

If an attack has succeeded, it will remain for the commander of the horse artillery to decide on the advisability of following the cavalry into the taken position, and further aiding in the pursuit.

Detached division.

One battery is attached to the advance guard, whilst its other three remain with the main body, but entirely at the disposal of the commander of the division, through its own commanding officer, and not at that of the commander of the main body.

Corps d'armée.

Formation.

Its advance guard will consist either exclusively of infantry, or of infantry and cavalry combined, the proportion of the one to the other depending on the nature of the country in which it may be acting. Generally one of its divisions forms the advance guard and the reserve, the other the main body, each retaining its own artillery (4 batteries), that of the former being attached to the advance guard exclusively, but in order to avoid an undue proportion of guns here, giving one or two of its batteries to the reserve artillery.

Should cavalry form part of the advance guard, a horse artillery battery will have to be withdrawn either from the cavalry division or from the reserve artillery and attached to it, being placed under the orders of the commanding officer of the artillery of the advance guard for the time. The artillery of an advance guard will consist, then, either of two 4-pr. batteries and two 6-pr.; of one 4-pr. and two 6-pr.; of one 4-pr., two 6-pr., and one horse artillery battery; or of one 4-pr., one 6-pr., and one horse artillery battery.

Artillery of an advance guard.

Horse artillery.

One, two, or sometimes three batteries of horse artillery will have to be attached to the cavalry of a corps, remaining always together under one commanding officer, and never being attached separately to the brigades.

Reserve artillery.

As has been shewn, the reserve artillery prepares for the attack of a corps, and constitutes, therefore, its main offensive element and not its reserve. The stronger, therefore, it is the better; but after the above deductions, the most it can consist of is one division of field batteries, one or two batteries of horse artillery, and the one or two batteries withdrawn from those of the advance guard—a strength which, if possible, should never be diminished.

On the march, in order to be capable of being used as above

suggested, artillery ought to march as near the head of a column as possible—viz., the artillery of the advance guard of a detached division immediately after the leading battalion, that of the main body of the division, or of the main body of the advance guard of a corps, at the head of such main body collected under one joint command, allowing one battalion or regiment to precede it.

Reserve artillery on the march.

The place of the reserve artillery on the march will depend on the order the corps may have to march in, either from the nature of the country or from other circumstances. Thus, in an open country, the reserve cavalry probably will precede its main body, in order to be able readily to succour the advance guard if attacked by the enemy's cavalry. The reserve artillery in this case might be placed under its protection and follow it in the column. As a rule, however, the reserve artillery will march under the protection of the main body of the infantry, one regiment or brigade preceding it, and in some extreme cases immediately "behind" the main body; never further back. But it has already been laid down that the divisional artillery of the main body should also march in rear of its first battalion. It must, however, give way to the reserve artillery if required, and march between the two brigades. It may be objected that the second infantry brigade will thus be thrown too far back; but be it remembered that the reserve artillery has to prepare for the attack, and will require to be some time in action in order sufficiently to shake the enemy before its infantry can attack, and that the depth of the ten batteries will occupy in column without second line of wagons 3000 yds.—a distance that can be traversed by infantry in 30 minutes, to which add the time required for forming columns of attack, &c. &c., and it will give just sufficient time to enable these guns to make a strong impression on the enemy. Horse artillery attached to cavalry marches in a body in rear of the leading squadron of its main body. No battery is given to its advance guard, whose duties are rather to feel than to fight, and consequently it will avoid a serious collision with an enemy; but if drawn into one, the batteries in the above position will be near enough to render it timely aid. Their aim must then be, by coming into action early and in masses, to prepare for the cavalry attack.

Clonmel,

March, 1871.

Note.—The above rules are intended for the Prussian artillery, which is divided into regiments of four divisions—three of field artillery and one of horse artillery, each of the former being composed of two 6-pr. and two 4-pr. batteries, the latter of three 4-pr. batteries. Such a regiment of fifteen batteries, or ninety guns, is attached to each *corps d'armée.*

THE STUDY OF NATURAL HISTORY.

A LECTURE DELIVERED AT THE R.A. INSTITUTION, WOOLWICH, OCT. 3, 1871,

BY

CANON KINGSLEY.

MAJOR-GENERAL F. M. EARDLEY-WILMOT IN THE CHAIR.

GENTLEMEN:—When I accepted the honour of lecturing here, I took for granted that so select an audience would expect from me not mere amusement, but somewhat of instruction; or if that be too ambitious a word for me to use, at least some fresh hint—if I were able to give you one—as to how they should fulfil the ideal of military men in such an age as this.

To touch on military matters, even had I been conversant with them, seemed to me an impertinence. I am bound to take for granted that every man knows his own business best, and I incline more and more to the opinion that military men should be left to work out the problems of their art for themselves, without the advice or criticism of civilians. But I hold—and I am sure that you will agree with me—that if the soldier is to be thus trusted by the nation, and left to himself to do his own work his own way, he must be educated in all practical matters as highly as the average of educated civilians. He must know all that they know, and his own art beside. Just as a clergyman, being a man plus a priest, is bound to be a man, and a good man, over and above his priesthood, so is the soldier bound to be a civilian, and a highly educated civilian, plus his soldierly qualities and acquirements.

It seemed to me, therefore, that I might, without impertinence, ask you to consider a branch of knowledge which is becoming yearly more and more important in the eyes of well-educated civilians—of which, therefore, the soldier ought at least to know something, in order to put him on a par with the general intelligence of the nation. I do not say that he is to devote much time to it, or to follow it up into specialities, but that he ought to be well grounded in its principles and methods; that he ought to be aware of its importance and its usefulness; that so, if he comes into contact—as he will more and more—with scientific men, he may understand them, respect them, befriend them, and be befriended by them in turn; and how desirable this last result is, I shall tell you hereafter.

There are those, I doubt not, among my audience who do not need the advice which I shall presume to give to-night; who belong to that fast increasing class among officers of whom I have often said—and I

have had scientific men cordially agree with me—that they are the most modest and the most teachable of men. But even in their case there can be no harm in going over deliberately a question of such importance—in putting it, as it were, into shape, and insisting on arguments which may perhaps not have occurred to some of them.

Let me, in the first place, reassure those—if any such there be—who may suppose, from the title of my lecture, that I am only going to recommend them to collect weeds and butterflies, "rats and mice, and such small deer." Far from it. The honourable title of Natural History has, and unwisely, been restricted too much of late years to the mere study of plants and animals; but I desire to restore the words to their original and proper meaning—the History of Nature; that is, of all that is born, and grows, in time—in short, of all natural objects.

If anyone shall say, By that definition you make not only geology and chemistry branches of natural history, but meteorology and astronomy likewise—I cannot deny it; they deal, each of them, with realms of Nature. Geology is, literally, the natural history of soils and lands; chemistry the natural history of compounds, organic and inorganic; meteorology the natural history of climates; astronomy the natural history of planetary and solar bodies. And more, you cannot now study deeply any branch of what is popularly called Natural History—that is, plants and animals—without finding it necessary to learn something, and more and more as you go deeper, of those very sciences. As the marvellous interdependence of all natural objects and forces unfolds itself more and more, so the once separate sciences, which treated of different classes of natural objects, are forced to interpenetrate, (as it were), and supplement themselves by knowledge borrowed from each other. Thus—to give a single instance—no man can now be a first-rate botanist unless he be also no mean meteorologist, no mean geologist, and—as Mr. Darwin has shown in his extraordinary discoveries about the fertilisation of plants by insects—no mean entomologist likewise.

It is difficult, therefore, and indeed somewhat unwise and unfair, to put any limit to the term Natural History, save that it shall deal only with nature and with matter, and shall not pretend—as some would have it do just now—to go out of its own sphere to meddle with moral and spiritual matters. But, for practical purposes, we may define the natural history of any given spot as the history of the causes which have made it what it is, and filled it with the natural objects which it holds. And if anyone would know how to study the natural history of a place, and how to write it, let him read—and if he has read its delightful pages in youth, read once again—that hitherto unrivalled little monograph, White's "History of Selborne;" and let him then try, by the light of improved science, to do for any district where he may be stationed what White did for Selborne nearly 100 years ago. Let him study its plants, its animals, its soils and rocks, and last, but not least, its scenery, as the total outcome of what the soils, and plants, and animals have made it. I say, have made it. How far the nature of the soils and the rocks will affect the scenery of a district may be well learnt from a very clever and interesting little book of Professor Geikie's on "The Scenery of Scotland, as affected by its

Geological Structure." How far the plants and trees affect not merely the general beauty, the richness or barrenness of a country, but also its very shape; the rate at which the hills are destroyed and washed into the lowland; the rate at which the seaboard is being removed by the action of waves—all these are branches of study which is becoming more and more important.

And even in the study of animals and their effects on the vegetation, questions of really deep interest will arise. You will find that certain plants and trees cannot thrive in a district, while others can, because the former are browsed down by cattle, or their seeds eaten by birds, and the latter are not; that certain seeds are carried in the coats of animals, or wafted abroad by winds—others are not; certain trees destroyed wholesale by insects, while others are not; that in a hundred ways the animal and vegetable life of a district act and react upon each other, and that the climate, the average temperature, the maximum and minimum temperatures, the rainfall, act on them, and in the case of the vegetation, are reacted on again by them. The diminution of rainfall by the destruction of forests, its increase by re-planting them, and the effect of both on the healthiness or unhealthiness of a place —as in the case of the Mauritius, where a once healthy island has become pestilential, seemingly from the clearing away of the vegetation on the banks of streams—all this, though to study it deeply requires a fair knowledge of meteorology, and even a science or two more, is surely well worth the attention of any educated man who is put in charge of the health and lives of human beings.

You will surely agree with me that the habit of mind required for such a study as this, is the very same as is required for successful military study. In fact, I should say that the same intellect which would develop into a great military man, would develop also into a great naturalist. I say, intellect. The military man would require —what the naturalist would not—over and above his intellect, a special force of will, in order to translate his theories into fact, and make his campaigns in the field and not merely on paper. But I am speaking only of the habit of mind required for study; of that inductive habit of mind which works, steadily and by rule, from the known to the unknown—that habit of mind of which it has been said:—"The habit of seeing; the habit of knowing what we see; the habit of discerning differences and likenesses; the habit of classifying accordingly; the habit of searching for hypotheses which shall connect and explain those classified facts; the habit of verifying these hypotheses by applying them to fresh facts; the habit of throwing them away bravely if they will not fit; the habit of general patience, diligence, accuracy, reverence for facts for their own sake, and love of truth for its own sake; in one word, the habit of reverent and implicit obedience to the laws of Nature, whatever they may be—these are not merely intellectual, but also moral habits, which will stand men in practical good stead in every affair of life, and in every question, even the most awful, which may come before us as rational and social beings." And specially valuable are they, surely, to the military man, the very essence of whose study, to be successful, lies first in continuous and accurate observation, and then in calm and judicious arrangement.

Therefore it is that I hold, and hold strongly, that the study of physical science, far from interfering with an officer's studies, much less unfitting for them, must assist him in them, by keeping his mind always in the very attitude and the very temper which they require.

If any smile at this theory of mine, let them recollect one curious fact: that perhaps the greatest captain of the old world was trained by perhaps the greatest philosopher of the old world—the father of Natural History; that Aristotle was the tutor of Alexander of Macedon. I do not fancy, of course, that Aristotle taught Alexander any Natural History. But this we know, that he taught him to use those very faculties by which Aristotle became a natural historian, and many things beside; that he called out in his pupil somewhat of his own extraordinary powers of observation, extraordinary powers of arrangement. He helped to make him a great general, but he helped to make him more—a great politician, coloniser, discoverer. He instilled into him such a sense of the importance of Natural History, that Alexander helped him nobly in his researches, and, if Athenæus is to be believed, gave him 800 talents towards perfecting his history of animals. Surely it is not too much to say that this close friendship between the natural philosopher and the soldier has changed the whole course of civilisation to this very day. Do not consider me Utopian when I tell you this. I should like to see the study of physical science an integral part of the curriculum of every military school. I would train the mind of the lad who was to become hereafter an officer in the army—and in the navy likewise—by accustoming him to careful observation of, and sound thought about, the face of nature—of the commonest objects under his feet, just as much as of the stars above his head; provided always that he learnt, not at second-hand from books, but where alone he can really learn either war or nature—in the field, by actual observation, actual experiment. A laboratory for chemical experiment is a good thing, it is true, as far as it goes; but I should prefer to the laboratory a naturalists' field club, such as are prospering now at several of the best public schools, certain that the boys would get more of sound inductive habits of mind, as well as more health, manliness, and cheerfulness, amid scenes to remember which will be a joy for ever, than they ever can by bending over retorts and crucibles, amid smells even to remember which is a pain for ever.

But I would, whether a field club existed or not, require of every young man entering the army or navy—indeed of every young man entering any liberal profession whatsoever—a fair knowledge, such as would enable him to pass an examination, in what the Germans call *Erd-kunde* (earth-lore)—in that knowledge of the face of the earth and of its products, for which we English have as yet cared so little that we have actually no English name for it, save the clumsy and questionable one of physical geography, and, I am sorry to say, hardly any readable school books about it, save Keith Johnstone's "Physical Atlas"—an acquaintance with which last I should certainly require of young men.

It does seem most strange—or rather will seem most strange 100 years hence—that we, the nation of colonies, the nation of sailors, the nation of foreign commerce, the nation of foreign military

stations, the nation of travellers for travelling's sake, the nation of which one man here and another there (as Schleiden sets forth in his book, "The Plant," in a charming ideal conversation at the Travellers' Club) has seen and enjoyed more of the wonders and beauties of this planet than the men of any nation, not even excepting the Germans—that this nation, I say, should as yet have done nothing, or all but nothing, to teach in her schools a knowledge of that planet, of which she needs to know more, and can if she will know more, than any other nation upon it.

As for the practical utility of such studies to a soldier, I only need, I trust, to hint at it to such an assembly as this. All must see of what advantage a rough knowledge of the botany of a district would be to an officer leading an exploring party, or engaged in bush warfare. To know what plants are poisonous; what plants, too, are eatable—and many more are eatable than is usually supposed; what plants yield oleaginous substances, whether for food or for other uses; what plants yield vegetable acids, as preventives of scurvy; what timbers are available for each of many different purposes; what will resist wet, salt-water, and the attacks of insects; what, again, can be used, at a pinch, for medicine or for styptics—and be sure, as a wise West Indian doctor once said to me, that there is more good medicine wild in the bush than there is in all the druggists' shops—surely all this is a knowledge not beneath the notice of any enterprising officer, above all of an officer of engineers. I only ask anyone who thinks that I may be in the right, to glance through the lists of useful vegetable products given in Lindley's "Vegetable Kingdom"—a miracle of learning—and see the vast field open still to a thoughtful and observant man, even while on service; and not to forget that such knowledge, if he should hereafter leave the service and settle, as many do, in a distant land, may be a solid help to his future prosperity. So strongly do I feel on this matter, that I should like to see some knowledge at least of Dr. Oliver's excellent little "First Book of Indian Botany" required of all officers going to our Indian Empire; but as that will not be, at least for many a year to come, I recommend any gentlemen going to India to get that book, and while away the hours of the outward voyage by acquiring knowledge which will be a continual source of interest, and it may be now and then of profit, to them during their stay abroad.

And for geology, again. I do not expect you all, or perhaps any of you, to become such botanists as General Monro, whose recent "Monograph of the Bamboos" is an honour to British botanists, and a proof of the scientific power which is to be found here and there among British officers; neither do I expect you to become such geologists as Sir Roderick Murchison, or even to add such a grand chapter to the history of extinct animals as Major Cantley did by his discoveries in the Sewalik Hills. Nevertheless, you can learn—and I should earnestly advise you to learn—geology and mineralogy enough to be of great use to you in your profession, and of use, too, should you relinquish your profession hereafter. It must be profitable for any man, and specially for you, to know how and where to find good limestone, building stone, road metal; it must be good to be able to distinguish ores and mineral products; it must be good to know—as a geologist will usually know,

even in a country which he sees for the first time—where water is likely to be found, and at what probable depth; it must be good to know whether the water is fit for drinking or not, whether it is unwholesome or merely muddy; it must be good to know what spots are likely to be healthy, and what unhealthy, for encamping. The two last questions depend, doubtless, on meteorological as well as geological accidents, but the answers to them will be most surely found out by the scientific man, because the facts connected with them are, like all other facts, determined by natural laws. After what one has heard, in past years, of barracks built in spots plainly pestilential; of soldiers encamped in ruined cities, reeking with the dirt and poison of centuries; of——But it is not my place to find fault; all I will say is, that the wise and humane officer, when once his eyes are opened to the practical value of physical science, will surely try to acquaint himself somewhat with those laws of drainage and of climate, geological, meteorological, chemical, which influence, often with terrible suddenness and fury, the health of whole armies. He will not find it beyond his province to ascertain the amount and period of rainfalls, the maxima of heat and of cold which his troops may have to endure, and many another point on which their health and efficiency—nay, their very life may depend, but which are now too exclusively delegated to the doctor, to whose province they do not really belong. For cure, I take the liberty of believing, is the duty of the medical officer; prevention, that of the military.

Thus much I can say just now—and there is much more to be said—on the practical uses of the study of Natural History. But let me remind you, on the other side, if Natural History will help you, you in return can help her; and would, I doubt not, help her, and help scientific men at home, if once you looked fairly and steadily at the immense importance of Natural History—of the knowledge of the "face of the earth." I believe that all will one day feel, more or less, that to know the earth *on* which we live, and the laws of it *by* which we live, is a sacred duty to ourselves, to our children after us, and to all whom we may have to command and to influence; aye, and a duty to God likewise. For is it not an act of common reverence and faith towards Him, if He has put us into a beautiful and wonderful place, and given us faculties by which we can see, and enjoy, and use that place—is it not a duty of reverence and faith towards Him to use these faculties, and to learn the lessons which He has laid open for us? If you feel that, as I say I think you all will some day feel, you will surely feel likewise that it will be a good deed—I do not say a necessary duty, but still a good deed and praiseworthy—to help physical science forward, and add your contributions, however small, to our general knowledge of the earth. And how much may be done for science by British officers, especially on foreign stations, I need not point out. I know that much has been done, chivalrously and well, by officers, and that men of science own them, and give them hearty thanks for their labours; but I should like, I confess, to see more done still. I should like to see every foreign station, what one or two highly-educated officers might easily make it—an advanced post of physical science, in regular communication with our scientific societies at home, sending to them accurate and methodic details of the natural history of each

district—details $\frac{99}{100}$ths of which might seem worthless in the eyes of the public, but which would all be precious in the eyes of scientific men, who know that no fact is really unimportant, and more, that while plodding patiently through seemingly unimportant facts, you may stumble on one of infinite importance, both scientific and practical. For the student of nature, gentlemen, if he will be but patient, diligent, methodical, is liable at any moment to the same good luck as befel Saul of old, when he went out to seek his father's asses, and found a kingdom.

There are those, lastly, who have neither time nor taste for the technicalities, the nice distinctions, of formal Natural History; who enjoy Nature, but as artists or as sportsmen, and not as men of science. Let them follow their bent freely: but let them not suppose that in following it they can do nothing towards enlarging our knowledge of Nature, especially when on foreign stations. So far from it, drawings ought always to be valuable, whether of plants, animals, or scenery, provided only they are accurate; and the more spirited and full of genius they are, the more accurate they are certain to be; for Nature being alive, a lifeless copy of her is necessarily an untrue copy. Most thankful to any officer for a mere sight of sketches will be the closet botanist, who, to his own sorrow, knows three-fourths of his plants only from dried specimens; or the closet zoologist, who knows his animals from skins and bones. And if anyone answers, But I cannot draw. I rejoin, You can at least photograph. If a young officer, going out to foreign parts, and knowing nothing at all about physical science, did me the honour to ask me what he could do for science, I should tell him, Learn to photograph; take photographs of every strange bit of rock-formation which strikes your fancy, and of every widely-extended view which may give a notion of the general lie of the country. Append, if you can, a note or two, saying whether a plain is rich or barren; whether the rock is sandstone, limestone, granitic, metamorphic, or volcanic lava; and if there be more rocks than one, which of them lies on the other; and send them to be exhibited at a meeting of the Geological Society. I doubt not that the learned gentlemen there will find in your photographs a valuable hint or two, for which they will be much obliged. I learnt, for instance, what seemed to me most valuable geological lessons, from mere glances at drawings—I believe from photographs—of the Abyssinian ranges about Magdala.

Or again, let a man, if he knows nothing of botany, not trouble himself with collecting and drying specimens; let him simply photograph every strange and new tree or plant he sees, to give a general notion of its species, its look; let him append, where he can, a photograph of its leafage, flower, fruit, and send them to Dr. Hooker, or any distinguished botanist, and he will find that, though he may know nothing of botany, he will have pretty certainly increased the knowledge of those who do know.

The sportsman, again—I mean the sportsman of that type which seems peculiar to these islands, who loves toil and danger for their own sakes; he surely is a naturalist, *ipso facto*, though he knows it not. He has those very habits of keen observation on which all sound knowledge of

nature is based; and he, if he will—as he may do without interfering with his sport—can study the habits of the animals among whom he spends wholesome and exciting days. You have only to look over such good old books as Williams' "Wild Sports of the East," Campbell's "Old Forest Ranger," Lloyd's "Scandinavian Adventures," and last, but not least, Waterton's "Wanderings," to see what valuable additions to true zoology—the knowledge of live creatures, not merely dead ones—British sportsmen have made, and still can make. And as for the employment of time, which often hangs so heavily on a soldier's hands, really I am ready to say, if you are neither men of science, or draughtsmen, or spórtsmen, why go and collect beetles. It is not very dignified, I know, nor exciting, but it will be something to do. It cannot harm you, if you take (as beetle hunters do) an india-rubber sheet to lie on; and it will certainly benefit science. Moreover, there will be a noble humility in the act. You will confess to the public that you consider yourself only fit to catch beetles, by which very confession you will prove yourself fit for much finer things than catching beetles; and meanwhile, as I said before, you will be at least out of harm's way. At a foreign barrack once, the happiest officer I met, because the most regularly employed, was one who spent his time in collecting butterflies. He knew nothing about them scientifically—not even their names. He took them simply for their wonderful beauty and variety; and in the hope, too (in which he was really scientific), that if he carefully kept every form which he saw, his collection might be of use some day to entomologists at home. A most pleasant gentleman he was, and, I doubt not, none the worse soldier for his butterfly catching. Commendable, also, in my eyes, was another officer (whom I have not the pleasure of knowing), who, on a remote foreign station, used wisely to escape from the temptations of the world into an entirely original and most pleasant hermitage. For finding (the story went) that many of the finest insects kept to the tree tops, and never came to ground at all, he used to settle himself among the boughs of some tree in the tropic forests, with a long-handled net and plenty of cigars, and pass his hours in that airy flower garden, making dashes every now and then at some splendid monster as it fluttered round his head. His example need not be followed by everyone; but it must be allowed that—at least as long as he was in his tree—he was neither dawdling, grumbling, spending money, or otherwise harming himself, and perhaps his fellow creatures, from sheer want of employment.

One word more and I have done. If I was allowed to give one special piece of advice to a young officer, whether of the army or navy, I would say:—Respect scientific men; associate with them; learn from them; find them to be, as you will usually, the most pleasant and instructive of companions: but always respect them. Allow them chivalrously, you who have an acknowledged rank, their yet unacknowledged rank, and treat them as all the world will treat them, in a higher and truer state of civilisation. They do not yet wear the Queen's uniform; they are not yet accepted servants of the State, as they will be in some more perfectly organised and civilised land; but they are soldiers nevertheless, and good soldiers and chivalrous, fighting their nation's battle, often on even less pay than you, and with still less chance of

promotion and less chance of fame, against most real and fatal enemies —against ignorance of the laws of this planet, and all the miseries which that ignorance begets. Honour them for their work; sympathise in it; give them a helping hand in it whenever you have an opportunity—and what opportunities you have, I have been trying to sketch for you to-night; and more, work at it yourselves whenever and wherever you can. Shew them that the spirit which animates them—the hatred of ignorance and disorder, and of their bestial consequences—animates you likewise; shew them that the habit of mind which they value in themselves—the habit of accurate observation and careful judgment—is your habit likewise; shew them that you value science, not merely because it gives better weapons of destruction and of defence, but because it helps you to become clear-headed, large-minded, able to take a just and accurate view of any subject which comes before you, and to cast away every old prejudice and every hasty judgment in the face of truth and of duty; and it will be better for you and for them.

But why? What need for the soldier and the man of science to fraternise just now? This need:—The two classes which will have an increasing, it may be a preponderating, influence on the fate of the human race for some time, will be the pupils of Aristotle and those of Alexander—the men of science and the soldiers. In spite of all appearances, and all declamations to the contrary, that is my firm conviction. They, and they alone, will be left to rule; because they alone, each in his own sphere, have learnt to obey. It is therefore most needful for the welfare of society that they should pull with, and not against each other; that they should understand each other, respect each other, take counsel with each other, supplement each other's defects, bring out each other's higher tendencies, counteract each other's lower ones. The scientific man has something to learn of you, gentlemen, which I doubt not that he will learn in good time. You, again, have (as I have been hinting to you to-night) something to learn of him, which you, I doubt not, will learn in good time likewise. Repeat, each of you according to his powers, the old friendship between Aristotle and Alexander; and so, from the sympathy and co-operation of you two, a class of thinkers and actors may yet arise which can save this nation, and the other civilised nations of the world, from that of which I had rather not speak, and wish that I did not think, too often and too earnestly.

I may be a dreamer: and I may consider, in my turn, as wilder dreamers than myself, certain persons who fancy that their only business in life is to make money, the scientific man's only business to show them how to make money, and the soldier's only business to guard their money for them. Be that as it may, the finest type of civilised man which we are likely to see for some generations to come, will be produced by a combination of the truly military with the truly scientific man. I say, I may be a dreamer: but you at least, as well as my scientific friends, will bear with me; for my dream is to your honour.

October 3, 1871.

THE USE OF RAILROADS IN TIME OF WAR.

COMMUNICATED BY

MAJOR-GENERAL SIR DAVID WOOD, K.C.B.

In the beginning of the war between France and Prussia, in 1869, railroads were so much used on both sides, that everybody who would rightly understand this and all following wars must make himself acquainted with the extent to which railroads can be used for warlike purposes. Some undertakings failed because the railroad was used, and the success of others was hindered because it was discovered, too late, that they could not be carried out without the railroad. Some delays were met with on the Prussian side which appeared incomprehensible, because a railroad which was thought to be available was not so; and, again, others were caused by neglecting to use a railroad which was really available. Sometimes too much, sometimes too little has been expected of them; and their importance has been at times as much over as under-rated by both nations.

A railroad will convey a certain amount of weight, with sufficient rolling stock, in a certain direction, in a certain time, for a certain distance.

1. The railroad is only of use in certain directions. In this it differs from every other mode of progress. When troops march, they can, if necessary, change their direction at any moment; but by the railway they must follow the direction of its lines, and only where these cross each other can they take another; therefore, if the enemy knows that troops are advancing by rail, he can easily guess the points from which the attack may be expected. Besides, it follows from this limited power of direction, that the troops being transported by rail must be covered by other troops not on the railway; and as, for long distances, it is seldom that enough troops are available to cover all places which the railroad passes, and as a knowledge of the transport at any place—even thirty or more miles distant from the assembling point—is sufficient to disclose this point, so it happens that, against a watchful and enterprising enemy, it cannot be expected that an undertaking which is based upon the use of the railroad can remain concealed, except when it is directed straight upon the enemy's front, and is covered by advanced troops. These are the operations which in war lead to definitive results—in which, however, each division, by a simple retreat upon its supports, can call for a fresh decision. Those attacks upon the enemy's flanks which are fatal to

one or the other side, can, however, never remain long concealed when they are conducted by railway.

2. Advance by railroad requires sufficient rolling stock. Only in railway carriages—which again can only be used on railroads and drawn by locomotives—can troops, &c., be conveyed on railroads. There is a sufficiency of rolling stock, either when there are enough carriages at the starting point for the whole advancing body of troops, or when there are at least sufficient for the first empty train to have returned to the starting point before the last has left. In the latter case, the carriages are sufficient for any weight that the railroad can convey. Even this simple truth has not been everywhere remembered, and the delay in the transport of the enormous siege-train for Paris was chiefly due to the over-estimate which was made of the disposable carriages. The German railways are mostly private undertakings, and have all of them very little more rolling stock than is required in time of peace; if the state wishes to secure itself against a time of war, it is its business, not that of the private company, to procure in time of peace a sufficient number of carriages for that purpose. In the same way as cannons, vessels, and weapons are kept in arsenals, so also could railway engines and carriages be prepared for a time of war. Properly managed, the expense would not be great, as the company would always place at the disposal of the state its whole material, which would only require to be supplemented. There should be proper carriages, too, for the transport of the wounded and for ammunition.

3. A railroad will convey only a certain weight, in a certain time, for a certain distance. The consideration of these three conditions—which, however, are really only one, as they depend one upon the other—is perfectly indispensable for the proper use of railroads in time of war. The weight to be moved must of course depend upon the available moving power. Strong engines can draw, upon lines with no steep inclines, in one train—*a*, 1000 men (infantry), with their complement of wagons and horses; *b*, a squadron and a half, or 225 men (cavalry), with horses and baggage; *c*, a battery, or six guns, with men, horses, gun and ammunition carriages; *d*, a light pontoon train; *e*, two light or one heavy field hospital; *f*, rather more than half a provision or ammunition train. The general strength of a German army corps is—25 battalions infantry, 6 cavalry regiments, 16 batteries, 1 pioneer battalion with a light pontoon train, 3 light and 1 heavy field hospitals, and at least 8 provision or ammunition trains; therefore it would require—

	Trains.
For the Staff	3
" Infantry	25
" Cavalry	18
" Artillery	16
" Battalion of pioneers	1
" Light pontoon train	1
" Field hospital	3
" Ammunition and provisions	16
Total	83

In case of necessity, perhaps part of the field hospital and the two trains for the pioneers, and the pontoon train, may be left behind, as well as, for

a short time, the ammunition and provisions; so that advancing to a battle the number of trains may be reduced to 64. The time is made up of that which one train requires to run the whole distance, added to the intervals necessary between each train and its successor.

A military train laden as above, consists of from 60 to 80 carriages, and therefore can travel only at the rate of a heavy goods train, besides having to make pauses at the different stations; the greatest speed, therefore, which may be safely reckoned upon is between 30 and 36 German miles (140 to 170 miles English) in the 24 hours. The time between the trains depends of course upon the line being single or double, unless there are enough trains at the starting point for the whole transport, so that none need be returned. This, however, can only occur when the transport is very small, so may be quite left out of the question. On double lines, the return of the empty trains need cause no delay. With only a single line, the trains must pass each other at the stations. As the trains are of great length, this cannot be done at all stations; one train must wait for the other, and even with the best order there must be much longer intervals between the trains.

At stations which have been determined upon before, the men must be fed and horses watered. Even with the best preparations this cannot take less than an hour, not including the getting in and out.

All these causes make, even on a double line, an interval of two hours necessary from train to train, which on a single line must be increased to three hours. Only when the distance to be traversed by the railroad is so short that it can be done without refreshment for the troops—that is to say, in 12 hours—can the trains follow each other every half-hour. If one really wishes to go safely and avoid all stoppages, an entire pause of four hours during the day should be made, for the removal of any obstacles or the repair of any breakage, which only allows daily for the advance of troops—

	Trains.
Upon single lines	6–7
Upon double lines	10

If the line of rail is in parts single and in parts double, it is safest to regard the whole as a single line.

According to the above rules, 36,000 men in fighting order require for a journey of from 30 to 36 miles—first, for the time when they are actually moving, 1 day; then, according to the rate at which trains can run on a double line, $8\frac{3}{10}$ days, on a single line about 13 days; so that in the first case $9\frac{3}{10}$, in the second 14 days, are required before the troops are all at their destination. At any rate, on the second day a certain number arrives, which is repeated every other day, and is ready for use; but if these are not enough, and the whole force is wanted, there must be an additional time of, on a double line 7, on a single line 11 days. If, on the other hand, the troops are marched, whenever they arrive they are all ready to fight. They can in 7 days march 18 miles (84 miles English), in 11 days 27 miles (126 miles English), without making forced marches. From this it follows that when the distance is 18 miles or less, a body of 36,000 men will reach their destination sooner by marching than if sent by a double line of railroad, and up to a distance of 27 miles, marching will be preferable in point of time to a single line of rails.

If the troops are not immediately wanted and the march by no means hurried, then the 36,000 men would arrive sooner by a double railroad than by marching, when the distance does not exceed 21 miles (98 miles English), and the times by marching and by a single line of rails would be about equal.

From these calculations one short law can be deduced for the movement of great masses of troops: that by double lines troops can only be brought into battle by the railroad with advantage when the number of German miles is more than half the number of thousands of the troops (English miles $2\frac{1}{2}$ times the number of thousands), and by single lines only when it is three-fourths of that number (English miles $3\frac{1}{2}$ times the number of thousands, nearly); and for ordinary purposes by a double line, when the number of miles is $\frac{7}{12}$ths of the number of thousands of the troops (English miles $2\frac{1}{2}$ times the number of thousands), and by a single line when it is more than the number of the troops (English miles $4\frac{1}{2}$ times the number of thousands). For instance, 60,000 men which are wanted for battle will arrive at the same time from a distance of 30 miles (140 miles English) whether they go by rail or march; under 30 miles they will arrive sooner marching, over 30 sooner by rail. Where the line is single they will march 45 miles (210 miles English) in the same time as they would take by rail, under 45 miles they will arrive sooner marching, over 45 miles sooner by rail. Thus it all depends upon the length of the march. But even for short distances, the transport of troops by the rail saves time for the infantry. Upon a double line of railway, at least 10,000 men, upon a single line 7000 men, can be sent daily. Cavalry and artillery could then march; these can easily go from 4 to 5 miles a day (say 19 to 23 miles English) for three or four days. By these means 50,000 may in four days be moved upon a point which is from 16 to 19 miles (75 to 89 miles English) distant. This the French could have done several times. They would have done it to great advantage in the second fight round Orleans, during the battles in and round the woods of Marchenoir; but the idea never seems to have entered into General Chanzy's head.

But the general must not lose sight of the moral effect upon the troops when he decides to convey them by rail. It is unavoidably prejudicial to discipline; therefore young troops should not be sent by it. For them, every day on the railroad diminishes their usefulness, and every day on the march is often an invaluable day of practice in the art of war. So the conveyance of troops is only one side of the question of the use of railroads; far more important is the second—the conveyance of provisions, the reserve weapons, and articles of clothing. In this the railroad does such good service that by its means alone can war on the large scale of the present day be carried on. Armies have become so large that the land will not support them if they have to remain long in one place. The stores are of course larger after the harvest, and less immediately before it; on an average, however, it may be reckoned that there are enough provisions for the inhabitants for 30 days. Thus, if the country to be occupied is inhabited by 150,000 men, therefore from 30 to 35 square miles (from 700 to 800 square miles English) in extent, 4,500,000 rations, those for women and children included, may be reckoned upon. If 150,000 soldiers are added to the number of inhabitants who require daily double rations, that gives only provisions for 10 days, when all goes well. If the enemy is equal in numbers,

on the sixth day they are at an end; and if what is generally lost in forced requisitions be reckoned, perhaps after three days want may be felt. Countries which are occupied for the second time yield much less; and if the war is at all stationary, it can only be carried on, even in the richest country, when the army by a regular supply makes itself independent of the resources of the place. A railroad, with five trains of 60 wagons each, can secure the sustenance of an army of 300,000 men and 60,000 horses for a day. As these trains do not stop, they can follow each other more closely—that is, at the rate of one every hour, not including the time taken for unloading. A train of 60 wagons, carrying 5 tons each, requires at least 10 hours for starting and unloading. If at the last station one train at a time only can be unloaded, the trains must follow each other every 10 hours only; but there is generally room for two trains to be unloaded, and they may then follow each other every 5 hours, and every day provisions for 300,000 men can be delivered.

The war material and the artillery for a siege are most difficult of conveyance by rail. A 24-pr. gun provided with 500 rounds, requires five wagons, and one train will forward 12 of them in one day 30 or 40 miles (140 or 190 miles English). Ten of such trains are sufficient for a whole siege battery of over 100 guns, with 500 rounds each; from 10 to 15 trains more would then bring all that the artilleryman or the engineer would further want.

December 1, 1871.

THE BAVARIAN "REVOLVER-CANNON."

BY

CAPTAIN E. BARING, R.A.

In the commencement of the year 1870, a paper appeared in the "Archives of the Prussian Artillery and Engineers," written by Capt. Count Thürheim, on the "Tactical value of the Revolver-Cannon." The weapon to which allusion was made was that invented by Feldl of Augsburg. The main conclusion at which the author arrived was, that the Revolver-cannon would be of little service to an army in the field, except in certain special cases, when acting strictly on the defensive.

During the war, a battery consisting of four of these guns was formed, placed under the command of Count Thürheim, and attached to the Bavarian corps of Von der Tann. A report of Count Thürheim's, dated December 30, 1870, is published in the current number of the "Archives." The following, without being a literal translation of this report, gives the most important points narrated in it.

The Revolver-cannon of Feldl consists of four parallel barrels, rifled on the Werder system. The diameter of the bore is 11 millimetres (·433 in.); the weight of the bullet is 22 grammes (about 12·4 drachms); the charge is 4·3 grammes (about 2·4 drachms). By a mechanical arrangement the fire can be spread laterally over an arc of 28°. It is possible to discharge 400 bullets in a minute from the four barrels, but practically 300 per minute may be said to be the maximum rate obtainable under ordinary circumstances. Each detachment consists of eight men, although only two are absolutely required to serve the gun. The following table shows the weight of the gun, limber, &c.:—

		lbs.
The gun		963
The limber, with 6864 rounds		1451
The gun and limber, and 2 men		2755
The ammunition wagon,* with 16,016 rounds.	Alone	3571
	With 5 men	4398

The gun and wagon are each drawn by four horses; in the former case each horse, therefore, draws 709 lbs., in the latter 1095 lbs.

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* The ammunition wagons of the captured French "canons de 4" were slightly altered, and used to carry the ammunition of the Revolver-cannon.

It has been incorrectly stated in some newspapers that the battery of Revolver-cannons took part in the action at Orleans on October 11th. This was not the case; one or two rounds were fired at Artenay, but the value of the battery cannot be said to have been put to any practical test until November 9th. On that day Count Thürheim was ordered to take part in the defence of the village of Culmiers. During the action the battery was divided into two detachments of two guns each, acting to a certain extent independently of each other. That detachment which Count Thürheim commanded in person came into action in a meadow, surrounded by hedges and ditches. The French infantry occupied ground about 700 or 800 yds. distant; they were forced to retreat under the fire of the Revolver-cannons. Count Thürheim then opened fire on a French battery of artillery, distant about 1200 yds., which also retired after a short engagement to a position out of range of the Revolver-cannons. Count Thürheim further claims to have driven back the advancing columns of French infantry three times. Eventually he retired, partially on account of the general retreat which was effected before the superior numbers which the French brought into the field, and partially because several barrels of his guns had become unserviceable by reason of the mechanical arrangements for loading and firing having got out of order. On leaving the village of Culmiers, one gun, which had still two barrels serviceable, was brought into action against infantry at 300 yds., but was almost immediately obliged to retreat, one of the two barrels becoming unserviceable after a few rounds. Count Thürheim does not give any details of the conduct of the detached division in action.

In conclusion, Count Thürheim states that the opinion which he had formerly expressed on the value of the Revolver-cannon in the field has been strengthened by the experience of the war. Six of such guns are capable of discharging 1800 bullets in a minute; a highly-trained rifleman, armed with the Werder rifle, can fire 24 shots in a minute. If, however, it be assumed that an average infantry soldier fires 9 shots per minute, it results that the fire of a battery of six Revolver-cannons, manned by 5 officers, 109 gunners and drivers, and 87 horses, may be regarded as equal to that of a company of 200 infantry soldiers. The fire of the infantry, Count Thürheim considers, will usually be much more effective than that of the battery, owing chiefly to the greater ease with which the individual rifleman can take advantage of the nature of the ground to get under cover. The Revolver-cannon will, therefore, be of little use in war, except in those cases in which, from insufficiency of cover, infantry cannot be deployed; for instance, in the defence of defiles or for flanking the ditches of fortresses. The effect of the fire of a 6-pr. battery of artillery will, in Count Thürheim's opinion, be always ("immer und immer") far greater than that of a battery of Revolver-cannons. If, however, it be thought advisable that weapons of this nature should accompany an army in the field, Count Thürheim thinks that they should not be formed into separate batteries, but that they should be attached to the ammunition columns, and used only in the event of the army being obliged to act strictly on the defensive, and to occupy some entrenched position.

The failure in the mechanism of the pieces, Count Thürheim accounts for by saying that they had been rapidly constructed, and had not been subjected to the necessary proofs before being issued. However this may be, there can be little doubt—both from the general tenor of Count Thürheim's report, and from the fact that the Revolver-cannons were at a later period of the war sent back into Germany—that the experiment may be regarded as a failure. Count Thürheim admits that the division of two guns under his own immediate command was singularly favoured by circumstances, and that the fire of the French infantry to which he was opposed was so wild as to be of little injury. Further, it is clear that the practice of the battery of artillery which Count Thürheim claims to have caused to retreat must have been exceptionally bad, since, after being in action for 1½ hours with 36 men and 32 horses, the Bavarian loss, both on account of infantry and artillery fire, amounted only to 1 officer, 1 non-commissioned officer, and 6 horses wounded, none of the horses being so severely wounded as to be placed *hors de combat*.

Topographical and Statistical Department
of the War Office,

April 6, 1871.

REMARKS ON THE

PROPER PROPORTION OF GUNS TO MEN.

BY

CAPTAIN E. BARING, R.A.

An interesting paper appeared at the commencement of the year 1870, in the "Archives of the Prussian Artillery and Engineers," on the subject of the most suitable proportion in which artillery could be combined with the other arms for service in the field ("über das Stärkeverhältniss der Feldartillerie zu den Andern Waffen-Gattungen.")

The author enters at considerable length into the subject, and states approximately what has been the usual proportion adopted in the various wars since the first introduction of artillery. During the wars of the 18th century, 3 guns per 1000 men was usually regarded as the normal standard, although in a great many cases the proportion was increased in favour of the artillery, and in some few cases it was diminished. Thus at the battle of Kolin the Austrians had 60,000 men and 162 guns (2·7 per 1000), the Prussians 32,000 men and 76 guns (2·4 per 1000); at Gross Jägerndorf the Russians had 90,000 and 300 guns (3·3 per 1000), at Zorndorf 50,000 men and 212 guns (4·2 per 1000); the Prussians at Zorndorf had 34,000 and 117 guns (3·4 per 1000), and at Leuthen 32,000 men and 167 guns (5·2 per 1000); the Austrians at Leuthen had 80,000 and 210 guns (2·6 per 1000). In the campaign of 1762, Frederic brought 67,000 men and 275 guns into the field (4·1 per 1000); the army of the Duke of Brunswick, which consisted rarely of more than 100,000 men, had from 220 to 280 guns attached to it (2·2 to 2·8 per 1000). In 1758 the French brought a very strong force of artillery into the field; the Swedish army, also, at the close of the war, consisted of 17,000 men and 70 guns (4·1 per 1000).

The maximum proportion of artillery to the other arms appears to have been attained at the time of the War of the Bavarian Succession (1778). The Prussians then brought 6 guns per 1000 men into the field, the Austrians 5½ per 1000; no general action, however, ensued during this campaign, which was, in fact, devoid of military incident, and can therefore scarcely be cited as a fair precedent.

During the early wars of the French Republic the allies encumbered

themselves with an undue proportion of artillery, which choked up the roads and hampered their movements. The rapid and incisive strategy of Napoleon necessitated, as a matter of course, a reduction in the number of guns which were brought into the field. Napoleon himself, as is well known, advocated 3 guns per 1000 as the *minimum* normal rate;* but, as a matter of fact, he rarely brought more than 2½ or 2 guns per 1000 men into the field, and sometimes even less. In 1805 the "Grande Armée" which marched on Ulm consisted, in the first instance (according to Thiers and De Fezensac), of 186,000 men and 340 guns (1·8 per 1000). The army which invaded Russia in 1812 consisted of 608,000 men and 1242 guns (2 guns per 1000).

Most European nations followed the example set by the French, and reduced the proportion of guns to men. Thus at Jena the Prussian army numbered 117,000 men and 280 guns (2·4 per 1000). Exceptional cases, however, occurred, in which a very large force of artillery was employed. In 1814, for instance, the allied army consisted of 405,300 men and as many as 1414 guns (3·5 per 1000). The Russians, also, continued to trust strongly in artillery; in 1812 the three armies which opposed the French invasion numbered collectively 195,000 men and 938 guns (4·8 per 1000). The French themselves, when they employed small bodies independently, exceeded the rate of 3 per 1000 considerably; for instance, at the battle of Brienne (1814), Ney's corps consisted of 35,000 men and 128 guns (3·7 per 1000), and at the battle which took place before Paris in the same year, Marmont's corps numbered 35,000 men and 154 guns (4·4 per 1000).

During the long period of peace which ensued after the battle of Waterloo, the most suitable proportion which guns should bear to men afforded a subject for frequent discussion; in the main, however, 3 guns per 1000 men continued to be regarded as the recognised normal rate, although some advocated the adoption of 3 guns per 1000 infantry and 4 guns per 1000 cavalry. A somewhat remarkable exception was afforded by the German Confederation, which in 1830 adopted 2 guns per 1000 as the standard proportion of artillery to the other arms. On the other hand, the Russians in the Crimea and the Austrians in 1859 brought a force of artillery into the field considerably in excess of 3 guns per 1000 men. On the whole it may be said that, as the size of armies increased, the proportion of guns brought into the field became relatively somewhat smaller.

Within the last few years, the introduction of rifled cannon and the enormous proportions which the armies of the continent have assumed, have introduced fresh elements into the discussion of the subject, which, according to the writer in the "Archives," have rendered it almost impossible to lay down a fixed rule which shall apply in all cases. An army of from 200,000 to 220,000 men will rarely advance by more than three, or at most four, parallel roads. Even supposing,

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* Although this is generally regarded as a maxim of Napoleon, it must be borne in mind that he was by no means constant in his opinion on this subject. In the "Commentaires" (Vol. VI. p. 167), he says:—"Il faut avoir autant d'artillerie que son ennemi, et calculer sur 4 pièces par 1000 hommes d'infanterie et de cavalerie."

therefore, that the train and the number of wagons and carriages which accompany the artillery be reduced to a minimum, the column will still be of such length that it would be a matter of difficulty to bring the guns in the rear into action on the same day as the head of the column was engaged. Colonel Reinländer, in his "Vorträge über die Taktik," a work recently published at Vienna, calculates that an Austrian army corps complete in everything requires 38,000 yds., or about 21½ English miles, of roadway. Colonel Borbstaedt, in his account of the war of 1866, states that a Prussian army corps takes up about 27 miles of roadway—18 miles being occupied by the troops themselves, and 9 miles by the ambulances, baggage, &c. Colonel Lewal, of the French army, in the "Conférence sur la marche d'un Corps d'Armée," enters at great length into this subject. He estimates that an army corps consisting of three divisions, or 39,323 men, marching on a single road, would take up 54,133 mêtres (33 miles, 1120 yds.), if the carriages were placed one behind the other, and 42,924 mêtres (26 miles, 1184 yds.), if the road were sufficiently broad to allow the carriages to march two abreast. I have not the requisite data at my command to calculate accurately the length of roadway which would be required by an English army corps, but I find, by a very rough calculation, that the infantry, cavalry, and artillery *only* of an army corps consisting of about 36,000 sabres and bayonets and 108 guns, would take up about 17½ miles of roadway.

If, therefore, the length of a column of route be compared with the ordinary rates at which experience has shown that troops are capable of moving, it will become at once apparent that to burthen large bodies of troops with an unduly great proportion of artillery is useless, from the impossibility of bringing the guns up to the scene of action within a reasonable period of time. Colonel Reinländer estimates that an ordinary day's march for an army corps is thirteen or fourteen miles, which will be performed in about eight hours if the roads are good; if, however, the road passes through hilly country, if the metal be bad and easily destroyed, or if the weather be unfavourable, a considerably longer time must be allowed. In 1866 the Austrian 8th Army Corps took 14 hours to march from Kasow to Nedelist, near Königgrätz, a distance of about 12 English miles, and the same corps in retreat took 16 hours to march 13 miles—namely, from Zadwersitz to Boikowitz; in the latter case the road was through a very hilly country. On the day of the battle of Sadowa, every effort was made to hasten the march of the Crown Prince; the weather was bad and the country hilly. The advanced guard of the 1st Division of the Guard, moving across country, marched from Doubrawitz to Jericek, a distance of 6 miles, in 2½ hours. Of this corps a French officer said, "Qu'il marchait à une allure extraordinairement accelérée." The main body of the army of the Crown Prince marched considerably slower. The 1st Corps, which bivouacked on the night before the battle at Chranstow, took, according to Colonel Borbstaedt, 9 hours to march 8 miles; and the 2nd Division of the Guard, which bivouacked at Rettendorf, marched 11½ miles in 10 hours. Cases have, indeed, occurred in which small bodies of well-disciplined troops have been moved with great celerity. The celebrated march of

the Light Division before the battle of Talavera is a well known case in point. I believe I am correct in stating that, during the Indian Mutiny, the 60th marched 80 miles in three nights. Probably the most rapid march on record of any large body of men, is that performed by the French army after the battle of Dresden. On this occasion, 80,000 men are said to have marched 30 miles a day for three consecutive days. But these cases must be regarded as wholly exceptional; as a general rule, it may be said that if a column exceed 10 or 12 miles in length, its deployment, save under very favourable circumstances, cannot be effected in less than 12 hours.

It is scarcely necessary to point out that the excessive length of a column of march is, in great measure, due to the artillery. A field battery on a war establishment takes up 473 yds. of roadway when in column of route; a horse artillery battery takes up 423 yds.; at least one-third of these distances would practically have to be added for loss of interval.

"It should not be forgotten," says the writer in the Prussian "Archives," "that every gun which is not brought into action is useless, and extends the length of the column unduly. . . . . . In the case of large armies, therefore, it would appear desirable to diminish the proportion of artillery to even less than 3 guns per 1000 men, both on account of the necessity of being able to move with ease and rapidity, and also because it is very improbable that so large a number of guns can ever be brought into action."

How far the truth of this remark is borne out by the events of the recent war, it would be premature to state before the incidents of each action are more accurately known. In Colonel Borbstaedt's history of the late war in France, a small portion only of which has been as yet published, the total strength of the French army is given as 460,000 men and 1344 guns, or very nearly 3 guns per 1000 men; the total strength of the army of the North German Confederation is given as 954,500 men and 1680 guns, or about 1·7 guns per 1000 men. In 1866 the Austrians at Königgrätz brought a very large number of guns into action, which did admirable service, especially after the retreat commenced. Some Austrian officers are of opinion that the proportion of artillery was unduly great, and one goes so far as to state that "the number of guns lost at Königgrätz represented precisely the undue excess of artillery in the Austrian army." The Austrian experiences at Königgrätz can scarcely, however, be regarded as conclusive in this matter, since Benedek awaited attack in a previously chosen defensive position. Under such circumstances the difficulty of bringing a large force of artillery into action would, of course, be comparatively small; this difficulty will always be experienced to a much greater degree when acting offensively.* Since, therefore, the primary object of every commander is to assume an offensive attitude rather than one of passive defence, it is clear that the standard organisation of an army should be such as will meet all the requirements of offensive war.

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* Colonel Stoffel, in his reports on the Prussian army, states that during the campaign of 1866 a third of the Prussian artillery never came into action.

It would appear, therefore, that the writer in the "Archives," whilst fully recognising the importance of artillery fire on a modern battle-field, is of opinion that it will be practically impossible to employ beyond a certain number of guns. Hence he infers that, in the organisation of large armies, the proportion of guns to men should never be more than 3 per 1000. He is careful, however, to point out that the case of smaller armies is wholly different. An army of from 70,000 to 75,000 men should, he considers, be able to deploy in about $3\frac{1}{2}$ or 4 hours, if marching by three or four parallel roads; the proportion of artillery should therefore be increased, since, in diminishing the total strength, the difficulty of bringing a number of guns simultaneously into action disappears, or, at all events, is much modified. At the battle of Custozza, the Archduke Albrecht had 75,000 men and 172 guns (2·3 per 1000). In spite of the ground being unfavourable to the action of artillery, there were several gaps in his line of battle into which some additional batteries could have been introduced with advantage; had the ground been favourable to the action of artillery, a larger proportion of that arm would have been absolutely necessary to him.

In conclusion, the writer in the "Archives" is of opinion that large armies acting in a flat open country, when the communications are good and numerous, should be provided with artillery in a proportion not greater than 3 guns per 1000 men; but that if the country be enclosed or mountainous, or the roads few and of bad quality, the proportion should not exceed 2 to $2\frac{1}{2}$ guns per 1000 men. On the other hand, he is of opinion that smaller armies of from 50,000 to 80,000 men should be provided with artillery in the proportion of at least $2\frac{1}{2}$ or 3 guns per 1000 men in mountainous and enclosed country; but that, if the theatre of war is favourable to the movement and action of artillery, the proportion should be increased to $3\frac{1}{2}$, $4\frac{1}{2}$, or even 5 guns per 1000 men.

Topographical and Statistical Department
of the War Office,

April 13, 1871.

A SHORT SKETCH

OF

THE RHINE FORTRESSES AND METZ.

BY

LIEUT. F. W. J. BARKER, R.A.

In bringing forward these few experiences, obtained during a short sojourn in Germany, I cannot hope to produce anything either very new or very original; I trust, however, that what I am about to write may prove of interest to some who have not yet had opportunities of seeing the routine and drills of German soldiers, and of visiting one of the finest lines of fortresses in the world.

Having made Bonn my head-quarters, I went down the Rhine to Deutz and Cologne, and afterwards returning through Bonn, visited the works of Ehrenbreitstein, Coblentz, Kastel, Mayence, Strasbourg, and Metz, seeing what I could of the soldiers in each of these fortresses. Before leaving Bonn I was asked to visit the Lazareth, which was occupied by wounded men. On entering the hospital I was unexpectedly brought face to face with some of the results of war, when the romance was gone and the excitement was over. The large, clean, and well-ventilated room was occupied by patients, many of whom had been crippled for nearly a year, and they were having their wounds dressed when I entered. As I passed through the wards and saw the poor fellows who had been reduced by one blow to a shattered existence and painful after-life, their patient and even hopeful endurance brought home to one a lesson in fortitude not easily to be forgotten. One man in particular, named Matheos Sohltz, was pointed out to me as remarkable even here for fortitude. This man had lost both feet just a year before, and hospital gangrene had set in; the diseased wounds had to be cauterised with irons heated to a white heat, and chloroform could not be used. One of those who saw the operation being performed, told me that the man submitted without a groan to the cruel tortures that caused even the practised attendants looking on to shudder, and the only evidence of his suffering was his putting the hospital blanket in his mouth and

crushing it between his teeth. He was a noble-looking fellow, with a broad brow and magnificently-cut features. When I saw him, there was a brave, manly smile on his determined-looking face.

The hospital was little different from our own, but the men were supplied with many little comforts and luxuries—such as flowers, fruit, tobacco, &c.—not usually seen among patients suffering from illness in peace time; and most of them puffed away at the well-known long pipe, which rarely left their mouths except when speaking, sleeping, or eating. Notwithstanding this continuous smoking, the air was fresh and the hospital clean, and free from the usual "disagreeables" of a smoking room.

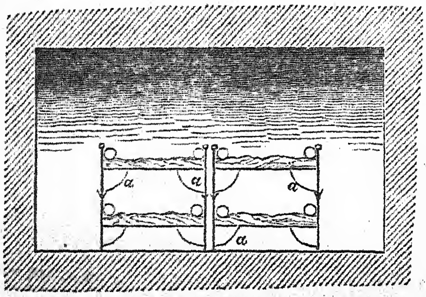
The first work which I had an opportunity of visiting was Deutz, the *tête-de-pont* of Cologne, and I must confess to a feeling of disappointment in seeing it. I walked round a portion of the work, and not being then acquainted with the Prussian means of preparation, I felt rather astonished to see only a few old guns in the terreplein of one salient, and none at all on the ramparts; no embrasures, and if the guns for arming the work were to be used *en barbette*, none of the usual arrangements for this kind of defence were visible. The guns which I saw were smooth-bore, both bronze and iron, some on high, unstable-looking, narrow iron garrison standing carriages, and some on travelling carriages. They looked to be about 18 or 24-prs., roughly sighted, and seemed like our own old guns, only used for drill purposes.

Cologne, which I afterwards visited, presented the same rough and *un*ready appearance that Deutz conveyed to the mind of the visitor; and but for the strength that its trace implied, it would have proved equally disappointing to one who desired to see a strong and fully prepared German fortress. There is, however, one striking feature about the defences of Cologne that attracts the attention of the visitor. This is, the double line of fortification on which the safety of the city depends; one line, the grand, lofty old wall of the fifteenth century, with its broad, deep fosses; and the other, the unpretending but really formidable earthworks and masonry of the present age of fortification. In these adjacent lines one can observe the contrast between ancient and modern fortification strikingly exemplified; for Archbishop Philip (who is said to have commenced the wall in the twelfth century) and his successors evidently considered that height meant security, and that a deep fosse and sufficiently high strong wall would enable the inhabitants of the city, as long as food lasted, to sleep as peacefully and live as contentedly through the most vigorous siege as if the besiegers were merely members of the Peace Conference making a demonstration. The line of works of the present century retains none of the characteristics of its progenitor (which, by the way, is now thrown into shade by trees, which usefully conceal its masonry), and occupies a lowly position not far removed from the foot of this well preserved old line of fortification, which is said to have been completed in the fifteenth century.

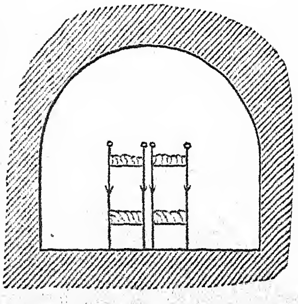
After my short visit to Deutz and Cologne, we proceeded to Coblentz, where we had an opportunity of visiting the well known Ehrenbreitstein. I confess to being greatly disappointed with the work, both as a natural fortress, and, as I had previously believed it to be, a triumph of fortification in producing a work of impregnable strength. Now, however, it seems to be nearly altogether dependent on its outworks, without which, in the

present era of artillery, the citadel itself would have a very small chance of a long defence. While on the summit of Ehrenbreitstein, I was much interested in what seemed a very true remark of the serjeant who accompanied us, and who noticed that my attention was directed towards one of the outworks on a hill that commanded our position. His remark was, "It would be 'all up' ('kaput gemacht') with Coblentz if that were taken." I need hardly add that the outwork is a strong one, and combines every one of the means of defence which the Germans so well know how to develop. I visited the interior of the casemate barracks on the summit of the rock (in which, by the way, I saw no guns), and was much struck by a simple method adopted for increasing barrack accommodation. In the centre of the casemate, and in line with the crest of the arch, the soldiers' beds are arranged in two tiers. The iron cots are so constructed that they can be placed one above the other, the feet of the upper tier fitting into sockets

Side Elevation.



End Elevation.



in the top of the lower tier; and thus twelve men can live in a small casemate without any crowding, and this arrangement of the cots allows a free circulation of air about them and through the casemate. The cots can be folded up, as the ends move on hinges or pivots, and they are kept rigid by means of a quadrantal bar (a), which also strengthens the light frame of the cot.

After visiting the interior of Ehrenbreitstein, I went round the exterior on the east and north-east sides, and there saw the formidable aspect of the work. The great masses of masonry, pierced with embrasures, looked very imposing, and perhaps, strictly speaking, more striking than formidable in a land work. The most prominent part of this mass of masonry is a semicircular bastion crowning the steep and almost precipitous slopes on the east side. This work, with its twenty-four embrasures in three tiers, offered to long-range and powerful guns a height and extent of masonry that, once shaken, would be liable to complete destruction.

On the other side of the river, I was able to see a German fort of modern construction. This was Fort Alexander, which is so well known by name in this country, and which holds a very high place in the estimation of the Prussians. I was fortunate enough to be able to visit the interior on the following day. This magnificent work is a striking example of the German

school of fortification, containing what are generally considered most of the distinctive features of that school, "le tracé angulaire substitué presque habituellement au tracé bastionné, la fortification perpendiculaire, les murailles isolées et les feux casematés."

Fort Alexander stands on a tongue of raised ground, or spur of a hill, between the Rhine and Moselle. Its high situation at the extremity of the spur protects its proper front from the danger of enfilade. Approaching it along the spur, the fortress presented a harmless and deceptively inoffensive appearance, with its grassy slopes, and not easily distinguished outline; but on approaching more nearly, the full strength of the work began to manifest itself, and on reaching the summit of the glacis and descending into the ditch, I became conscious of a power, both of direct and flank defence, that I could not have previously imagined, and such as I did not see in any of the other German fortresses, nor in Metz.

I have not space here to enter upon a detailed description of the work, with which many are acquainted, and which can be found in an interesting essay by Baron Maurice,* and in other works on fortification; I will merely remark that in passing from the glacis to the interior of the work, each place where I halted and looked round seemed specially singled out for a concentrated fire of small-arms and artillery, and I believe that this impression would be equally produced on the mind in any position which the visitor might select as a point of observation. The magnificent caponier in this face makes all the more impression on the visitor, as (unless previously acquainted with the plan of the work), one is quite unprepared for it; and when you imagine you are about to enter the main body of the work, you suddenly find yourself face to face with a strong fort with two tiers of guns, and hemmed in by revetments all round, so loopholed that they would form a deadly prison to any enemy rash enough to attempt an attack before their complete destruction. The caponier forms a fine barrack, and was clean-looking, whitewashed, and nicely kept when I saw it. On passing through a tunnel up an incline from the ditch, I reached the interior of the work, where there is a large open parade ground, containing only a few old guns and some piles of S.B. ammunition.

After visiting some of the other outworks of Coblentz, we proceeded to Mayence. I was much struck with the difference between this fortress and the one I had just left; Coblentz and its outworks having all the modern improvements for flank defence, protected casemates, loopholed galleries, &c., while Mayence, with its high escarp, bastioned trace, and imperfectly flanked ditches, is a type of a very different school of fortification. Some portions of Mayence, however, and most of its outworks, may be considered new. I had only time to visit and examine one of the lunettes at some distance from the body of the place. The work was a very small one, but, like most of those that I saw, very complete in details of construction; and the impression conveyed by even such a short visit as mine, was that the Prussians are determined not to leave even their lightest outworks open to chance of surprise, and to render them utterly untenable to any enemy attempting the same.

A glance at the accompanying rough sketch, Figs. 1 and 2, demonstrates

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* "Essai sur la Fortification Moderne," par le Baron P. Emile Maurice.

what I mean, and it can be seen that the work could not be held until both the barracks under the ramparts and the keep were destroyed.

Fig. 1.—Plan.

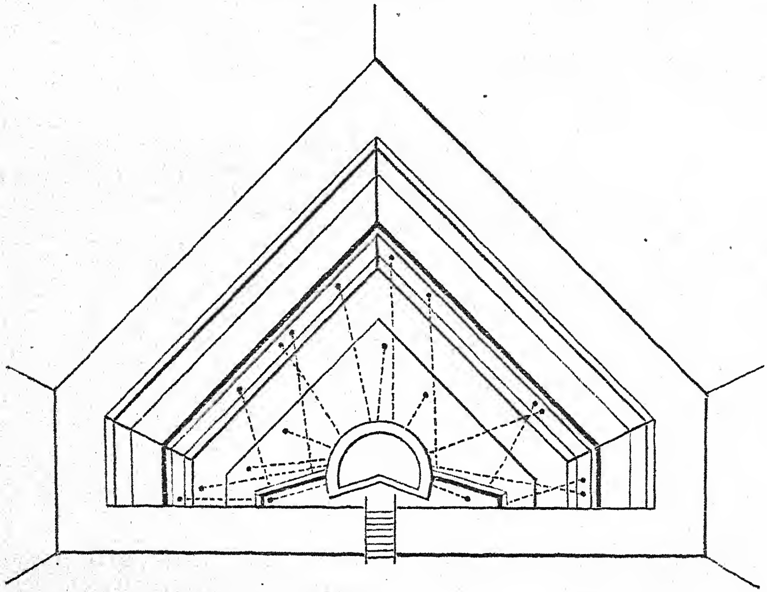
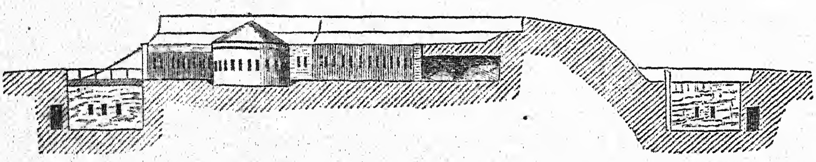


Fig. 2.—Section and Elevation.

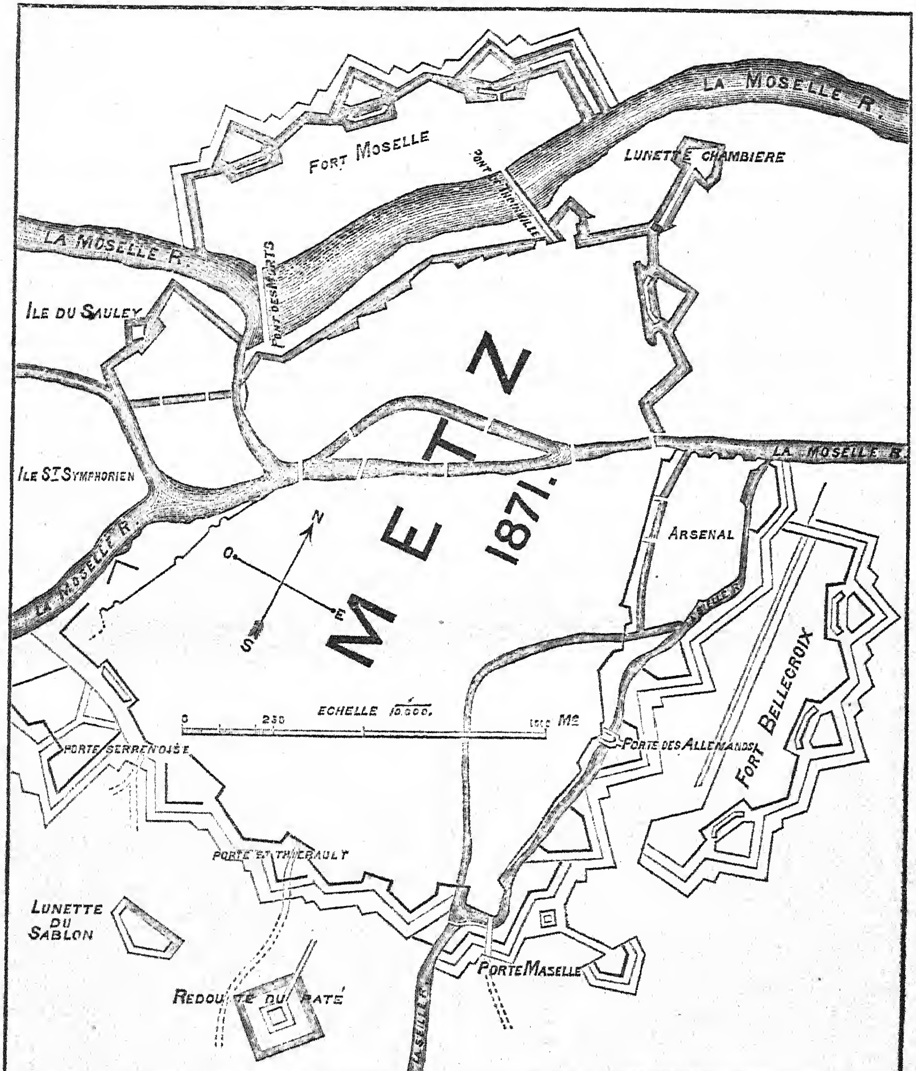


The above is a copy of a sketch which I made of one of the new outworks of Mayence, and it will, I trust, prove a suitable example to illustrate what I intended to convey.

The next work which I had an opportunity of visiting was Metz—a good type of the French school of fortification, and one which held, as is well known, a high reputation as a French fortress.

I must confess to a strong feeling of disappointment as I first entered the town and visited the ramparts constructed for an artillery of a past age, and saw the enormous amount of work expended in developing a defence so ill-adapted to the accurate and long-range fire of the rifled ordnance and small-arms of the present day. The general outline of Metz can be seen from the accompanying sketch (Fig. 3), and I have only time here to deal with one or two

FIG. 3.



points connected with the work and its garrison which strike the casual observer, before proceeding to mention the outworks, on which I believe the future fate of Metz will in any regular siege wholly depend.

The first striking feature in the fortification of the city is the immense excavation of ditch, and height of parapet and escarp revetment. This wall, on the south-east side, near Porte des Allemands, seemed nearly 50 ft. high, and the ditch, through which the river Seille flows, looked quite a little valley.

I believe that this part of the work is an adaptation of old Roman defences; and hence the amount of excavation and manual labour that appears to us extraordinary in these days of expensive labour and national debts.

The next feature of the defence of Metz is the adaptation of the water supply, by which the ditches can be flooded and much of the surrounding country inundated. This, it will be seen from the sketch, is greatly facilitated by the natural position of the city; and to this it owes one of its greatest claims to strength.

I had opportunities here, as well as at Coblentz, Mayence, and Strasbourg, of seeing something of the German soldiers, both in their full dress, or show trim, for muster parade, and in their working dress for drill and marching order. The full dress of dismounted soldiers of any nation, and the importance attached thereto, is a question open to much discussion. To me it seems that on these parades, each man, with the assistance of tailor, brushes, and pipe-clay, is supposed to do his best to look his best, and having accomplished this task, the only other duty that remains to him is to stand and be looked at. Consequently I must confess to not having devoted very much attention to the various uniforms I saw on parade under the trees of the esplanade at Metz, on the morning of the 31st August; I can merely state that cavalry, artillery, engineers, and infantry seemed well and suitably dressed. The men were, as a rule, fine-looking, and seemed capable of hard work, but not well "set up." I had a better opportunity of observing these soldiers on the drill ground on the following morning, when I saw two batteries, three infantry regiments, and some cavalry (Uhlans), at various drills, and spent more than an hour in seeing some of the men in their working dress who had won for themselves such a high reputation among the soldiers of Europe.

I confess that as a gunner I was considerably startled the first time I saw a Prussian battery turn out for drill. This was at Coblentz. The guns may have been clean (they were as usual covered, breech and muzzle), the carriages certainly were not, and so uncared for did they look that I afterwards went down to the gun-shed to see if cleaning were an after operation. They were in the same condition in the shed as on parade, and from what I afterwards saw of Prussian batteries, I conclude that cleaning, if done at all, is only considered necessary at very long intervals. I may also state that this is evidently *not* the painting season for batteries in the frontier fortresses. There was no attempt at burnishing any ironwork except the bits, stirrup-irons, and curb-chain. Harness serviceable but rough, and the batteries looking as if very little acquainted with water, and totally so with soap, but notwithstanding this, looking sound and serviceable.

The field artillery drill that I saw was chiefly elementary driving drill, and the remarks that I apply to those I saw this morning at Metz are applicable also to the batteries at Coblentz, Mainz, and Strasbourg. All the drills can better be described as painstaking than smart. Each mistake seemed to be pointed out in a methodical way, and corrected without the same quickness or smartness that is exhibited in the instruction of our soldiers. The driving, elementary though it was, showed me one evil of the pole draught, which, although probably well known to many, I cannot refrain from remarking upon. Whenever the battery wheeled at all sharply,

either to the right or left, the wheel-horse on the inner side of the circle seemed to suffer from striking his fore legs against the cross-bar (hooked on to the end of the pole), to which the traces are attached for the rest of the team. This will be easily understood when it is remembered that the pole has considerable play in a vertical direction, and consequently can rise nearly as high as the wheel horses' breast, or sink as low as below their knees, according as the draught is applied; and when the wheel takes place, the upward strain is not only converted into a lateral one, and the pole to a certain degree released and allowed to sink, but the cross-bar is also much inclined to the pole. The result of this was evident even in the action of some of the horses, as one could see them lift their fore legs as if they quite expected hard knocks. There was a good deal of attention shown in pointing and laying; quickness did not seem to be nearly so much considered as accuracy with the young hands.

The next soldiers I saw on parade were the Bavarians. These fellows I had seen the evening before at bayonet exercise, and marked the determined expression of their almost hairless faces as in two opposing ranks they went through points, thrusting towards one another with right good will. As I saw their firm-set mouths, and watched these small but wiry men handling their rifles with bayonet, I could well realise the stories told of them when they once became excited. This morning, however, they were in marching order, and going through battalion drill, which they performed in first-rate style, marching splendidly in line, "blocking up" well, and both deploying and forming square with wonderful quickness and precision. The square consisted of two ranks, and, to speak more accurately, was a rectangle. These men were armed with the Werder rifle (which, as most are aware, is very like the Martini-Henry with two triggers) and a short sword at their side, as well as the bayonet on the rifle; the ammunition pouch was on the waistbelt and in front. The cowskin knapsacks were fastened on with shoulder-straps, cloaks rolled round outside, and a good and useful water-bottle—like a tourist's very large flat brandy flask—hanging at the side, with a tin cup that fitted it at the bottom. The other regiments which I saw—Prussian infantry and Uhlans—are too well known to need description here.

Before leaving Metz I was able to see something of the outworks, and as most of them stand on considerable elevations above the town, the interior of which would be exposed to fire from them if once captured, I may perhaps be excused, at the risk of becoming tedious, if I offer a few observations regarding them. These works are Fort St. Quentin, Fort des Carrières, Fort St. Julien, Fort de Quealeau, and Fort de St. Privat, and the Prussians are at present busily engaged in strengthening and completing them, evidently fully realising their importance. One of the nearest and the most elevated, Fort St. Quentin, stands on a hill about 300 ft. high and 2100 yds. from Metz, and from it one can obtain a very good view of the interior of the city. From the heights of St. Quentin the observer has a good opportunity of speculating as to the most probable points of Metz on which long-range artillery fire would be directed; and as the city is built on a slope, the general direction of which is downwards towards the foot of the hill on which St. Quentin stands, one can obtain almost a bird's-eye view of the works. Forts St. Quentin and Carrières, left unfinished by the French, are now approaching completion; and from what I saw there I am led to believe

that the Prussians are not contented with outworks which seemed, under the French *régime*, rather a tardy recognition of a new era in artillery than the key to the position on which the safety of one of their largest fortresses depended. In position, St. Quentin appears to be to Metz what Fort Alexander is to Coblentz, and it seems probable that at no very distant period the visitor to Metz may find an outer line of defence, which will alter the now prevalent belief that the progress of the science of fortification is comparatively slow, and render no longer true the remarks of some authors on this subject.*

Should this outline sketch possess any interest to the readers of it, some may feel inclined to visit the same ground, to inspect more carefully than I had either time or opportunity for doing, and note more fully the result of their observations; and should the "jottings" they make call up as pleasant reminiscences to them as mine did to me, they will have no cause to regret a visit which gives them some knowledge of the Rhine fortresses and German soldiers.

SHOEBURYNESS,

October 17, 1871.

* "D'immenses progrès ont été réalisés dans toutes les branches de l'art de la guerre; la fortification seule est restée à peu près immobile."—Etudes sur la Défense des Etats, par M. le Major Brialmont.

AUTUMN MANŒUVRES;

CONSIDERED IN THEIR PLACE BETWEEN DRILLS AND WAR.

A LECTURE DELIVERED AT THE R.A. INSTITUTION, WOOLWICH, DEC. 19, 1871,

BY

CAPTAIN C. B. BRACKENBURY, R.A.

Brigadier-General J. M. Adye, C.B., R.A., in the Chair.

In the time of the Crimean War, it happened to me once to ride with a companion through the valley of Baidar. The well known archway was held by a French guard—one of the advanced posts of the allies in that direction. With the usual coolness of Englishmen we rode straight through the astonished French soldiers, quite heedless of their surprise, until, when we had passed on a few paces, there was a marked movement among them, and we were ordered back in no friendly tone. It was evident that the command would be followed by a bullet if not obeyed, so we turned back, chafing at what we supposed to be the insolence of our allies. An officer came out, and enquired what was our business there. "No business; only a ride for pleasure," we replied. At first he was somewhat incredulous, as well he might be, but soon believed our word, and treated us with every kindness, sending us some grapes and wine. "But gentlemen," he said, in an expostulatory tone, "how could you ride through the advanced posts of an army without business, without pass-word, without even deigning to speak to the officer in charge of the post. *You know war*, and that such conduct is very dangerous." "*Know war!*" that was just what I was quite certain I did not, whatever my companion might know. I knew how to take care of horses, drill a troop of horse artillery, or make up weekly mess-books; but this thing called "War." What was it? and how came it to be possible that I could make such a blunder as this without knowing it? The episode might have happened to any one of the thousands of officers who knew no more than I did. May we not fear—nay, are we not certain, that many a gallant life was thrown away in striving with desperate bravery to make up for want of knowledge of "War.". While we are proud of the Alma, we should not forget that a sustained pursuit would probably have been rewarded by the capture of the fortress. The lustre of the gallant deeds done in the plains of Balaklava must not blind us to the memories of mud on the winter way and muddle in the port. In our pride of those who stood gloriously on the slopes of Inkerman, let us remember also those

who lie on Cathcart's Hill. In the early part of the campaign, Englishmen gained an imperishable name for bravery, but they threw away their light cavalry. Later on, they won Sebastopol, but lost an army. Since then the knowledge of war in the English service has advanced steadily, step by step, as on a ladder; each step being toilsome, but affording foothold from whence to attempt another movement of progress. So that one of the wisest and cleverest of our late foreign visitors, who knew us well, both at the Crimean time and ten years later, is able to say that he is fairly astonished at the progress made; but the same officer is of opinion that we have still much to learn. There will be some to say—"What! is the splendidly-appointed English army to learn from continental soldiers?" Yes, gentlemen, we have still much to learn. Remember the confidence with which all looked forward in 1866 to the triumph of the Austrians. No soldiers could have fought more gallantly or with more dogged resolution; yet you know the result. You must have read, too—everybody has read it—the Archduke Albert's pamphlet on "Responsibility in War," published in 1869, when that Imperial Prince was devoting his whole attention to the reorganisation of the Austrian army. You remember the passage where he speaks of the "exaggerations and trifles" of peace among soldiers who passed their life in the service. He says:—"They thought it their duty to be continually occupied, and were led into refinements, into exaggerations in the uniformity and elegance of dress and equipment, of manual exercises with arms, and of movements. Narrow intellects excelled in these arts, acquired thereby ill-merited reputations, but rendered the service insipid, and checked the intelligent soaring as well as the advancement of more gifted officers." Beauty of uniform and nicety of step and carriage on parade are excellent things in their way, but fatal to the man who regards them as the one thing needful of soldiering. They are but as the polish of the pieces and of the board in a game of chess—not at all to be despised for their moral effect, but entirely subordinate to the knowledge of the game.

What has the student of chess to learn? First, the movements and power of the pieces. This corresponds with the movements of various troops in war. "Everybody knows this!" Not so. At the late manœuvres, the miscalculations of time in which marches could be made was quite extraordinary—so much so as to defeat almost every attempt made at combined movements. Then, at chess, in the early part of our progress, we have to learn a few openings and combinations of action among the pieces to attain a certain end, corresponding with the handling of the three arms—infantry, cavalry, and artillery—under different circumstances and for different purposes. In our knowledge of this, as soldiers, it must be confessed that our visitors, learned in war, found us eminently deficient. Each English officer could drill his own men, but too many were embarrassed when those of another branch were put under their hands. The remedy for this want of knowledge is plain. In other countries, comparatively junior officers are given all three arms to handle. Surprise at the want of such a system in England was expressed by our foreign visitors, as it is by all soldiers who know civilised warfare. We must learn to walk before we can fly. There is nothing in the profession of the soldier to free him from the old necessity so well expressed in the proverb, "There is no royal road to learning." It is said that "Poeta nascitur non fit," but even poets have to plume their young

wings ere they can take flight in epic strains. We can expect but few real poets in an age; we *must* have real soldiers. The great strategical and tactical efforts of masters are fully comprehended by but few in any army; still fewer are they who can originate them. It does not follow that all should not have opportunity given them for proving their abilities. Here our simile must cease; for we do not play in war with dead pieces, but with living men, who must be fed, and clad, and provided with weapons and ammunition, not only at the beginning of a campaign, but all through it.

There was, this autumn, great difficulty in supplying for one fortnight thirty thousand men, from depôts in the centre of a space occupied by three divisions, close to London, and in time of profound peace. How should we have fared if the war had been real, and the divisions moving every day farther and farther from the base of operations? The only way to test the supply departments is by actual work, as nearly approaching that of war as we can get. If they are not strong enough in transport, or have not experience enough to feed the troops for a fortnight during the autumn manœuvres without many a mishap, it would be little less than madness to trust them under far more difficult circumstances, when the honour of England is in their hands. Gallantry may win a fight in spite of many errors, but it will not feed men—nay, it is itself partly dependent on bodily nourishment. The supply departments are young yet, and have few opportunities for practising their work—one of the most elaborate as it is also one of the most necessary branches of the art of war. They must have time and experience in supplying armies before perfect confidence can be placed in them.

Besides the two main objects of such manœuvres—practice of tactics and of the supply of an army with provisions—there are many other branches of military knowledge included in "knowing war," which can only be properly learned, or at least proved, in such peace manœuvres as will best represent real work in the field. There are, for instance, the whole of the duties of the staff—including that most important one, acquiring and digesting information, without which generals can but blunder in the dark. It may be admitted that full knowledge of such duties can only be acquired by service against an actual enemy in the field; but we may approach very nearly the conditions of warfare if we set our minds to it. In the absence of foxes, we hunt a drag for practice of hounds, horses, and men; free military manœuvres are the drag-hunting and cub-hunting of war. It is a remarkable fact that the undoubted ability and knowledge of the Prussian generals and staff were acquired in time of profound peace, and they themselves say that their school was the autumn manœuvres. Unfortunately, we in England can hardly hope to approach the conditions which render the Prussian imitation of war so close and so instructive. Up to the present moment, it is not thought possible to dispense with tents, and place the men in cantonments, or bivouac, according to the weather. We cannot place the inhabitants of a district under contribution, and we are obliged to avoid the occupation of many portions of the territory which should be free for the march of the armies. We can, however, do much; and when we look at the intense interest in the late manœuvres manifested throughout the country, and the anxiety of certain counties to be the scene of the mimic campaign, we may fairly entertain the comfortable hope that the autumn manœuvres will become popular in England, and be regarded almost as a national sport.

There are two principal ways in vogue on the continent for practising troops in the art of war—the autumn manœuvres of Prussia and Russia, and the permanent camps of instruction of France and Austria. We all know what the Prussian manœuvres are like, and some extremely interesting letters in the "Times," from Lt.-Col. Money, N.E. London Rifle Volunteers, gave us lately a description of the Russian manœuvres, during which a whole district was in a state of siege, and the capital city, St. Petersburgh, ordered to be considered by the generals as non-existent, except as affording a peculiar combination of roads. Up to the time of the late war, the French had Chalons as their camp of instruction, where regular divisions were formed, and after the usual battalion and brigade drills, came great manœuvres, with their beginning and end laid down beforehand. These were useful, in so far as they gave the generals practice in handling bodies of men; they were all but useless as far as headwork is concerned. The present Austrian system is a combination of the French and the Prussian. They have their great standing camp at Bruck, but their manœuvres are much freer than those of the French, the generals being actually pitted against each other. Each year the Minister of War brings forward a proposal for grand manœuvres over a wide extent of country, but hitherto the design has not been carried out completely, from want of money. Everybody in Austria considers the scheme a most valuable one. We in England have our camp of instruction at Aldershot. Its first establishment was a great step out of the monotonous marchings of the barrack square; the generals obtained some practice in handling mixed bodies of troops, and both officers and men gained a good deal of real instruction. But Aldershot, like Chalons and Bruck, has one great disadvantage, when compared with the district manœuvres of Prussia. Every bit of the ground becomes as well known to the commanders as their own quarters, and the limited number of combinations possible, when all the necessities of the case are taken into consideration, have long ago been exhausted. We want space for our manœuvres in districts not so well known but that everybody will have to make use of his map.

Yet see how we have grown. From barrack-square drills to a small camp at Chobham, where much the same drills were carried out; from Chobham to Aldershot, with its increased number of troops and its set manœuvres; from the set manœuvres to a certain amount of freedom in the tactics of one commander against another. After this came the establishment of umpires, whose main business is really to take care that the losses occasioned by mistakes should become palpable, and to prevent actual blows. Lastly, we have had the autumn manœuvres of 1871—timid and tentative, but affording a grand platform on which to rest and gather strength for the next spring upwards. Verily there is reason for triumphant hope. Perfect as it is now in the material to make soldiers and generals out of; perfect in spirit, courage, loyalty, and discipline; admirable in equipment and armament; who can doubt that the British army will be first in the knowledge of this thing called War, now that the chance is given to it?

There is one point to which attention is needful. It seems a little rash to bring up regiments and batteries from country quarters, throw them hastily into divisions, and expect them to reap the full benefit of the manœuvres. The Prussian district-corps organisation makes it a simple problem to begin with company drill every year, go on to battalion move-

ments, then throw battalions into brigades, brigades into divisions, divisions into corps—drilling the men from lower to higher, and practising first the junior, later on the senior officers. With us it is not so easy, yet neither is it so hard but that the difficulty may be surmounted. Might it not be well to concentrate small detachments of the three arms in camp on country commons, and let field officers and even captains have commands occasionally for special purposes—such, for instance, as enacting the work of advanced or rear guards in presence of an enemy, passage of bridges, attack of villages, or reconnaissances? The superior officers could look on, not interfering at the time, but criticising afterwards, and awarding praise or blame according to circumstances. By such practice much would be learnt, and I humbly submit that fewer mistakes would be made than occurred last September. Now that the power of firearms has been so enormously developed, battles are, more than ever, a series of struggles for positions, sometimes by very small bodies of troops. In the half-dozen or so of great battles and the numerous skirmishes at which I have been so fortunate as to be present, I never once saw lines of men standing opposite to each other at a couple of hundred yards' distance and blazing away as we saw them doing at the manœuvres this year.* There is always a heavy fire of artillery and much skirmishing for a considerable time, then a concentration of men—sometimes a strong column, sometimes only a company—a rush, and an advantage gained, by one side or the other, such as affects the whole battle. At the great battle of Königgratz it was but a very small force which, well and boldly led, first slipped almost unnoticed into Chlum, and spread consternation throughout the whole Austrian army—for the small Prussian force stood behind the Austrian centre. It would be easy to name many cases in which slender detachments of the three arms may do great things. Surely a general would not be put to command them. Besides, does it not seem unnatural to expect men suddenly to know how to command a brigade in action when they have never commanded a mixed force of a thousand men in their lives. Athênê may have sprung, fully armed and invested with all wisdom, from the head of Zeus, but it would be a little presumptuous in us to fancy we can do the same. Even the Greek demi-gods had invariably to undergo some sort of probation before they undertook their great labours; and proud as we may well be of the roll of famous English generals, we shall find, on examination, that they all, or nearly all, served an apprenticeship to war in the junior ranks. If we cannot have war—civilised war, I mean, with well-taught armies—we must get what learning and practice is possible in peace.

Infantry, Cavalry, Intelligence.

Of the two great divisions of the art of handling armies, strategy and tactics, the former is best capable of being studied theoretically, and least able to be put in practice during peace manœuvres. On the 13th September a "General Sketch of Manœuvres" was issued, giving a strategical idea to

* "At 300 yds. it (the fire of infantry), becomes decisive; and the effect of infantry at 100 yds. may be called *annihilating*."—Employment of Field Artillery in combination with the other Arms, by Kraft, Prince of Hohenlohe-Ingelfingen. Translated by Captain F. C. H. Clarke, R.A.

work upon; but it was not intended to be of more use than to give some public interest to the campaign, by calling one force the enemy of England and another the defenders. To soldiers it mattered little how far-fetched the idea was—there were two armies, one trying to get to London, the other to prevent it. Furthermore, at first it was uncertain whether the resources of the supply departments would admit of the formation and active motion of a third division; indeed the question of supply had to be put, from beginning to end, above all strategical maxims. It was quite unfair to criticise, as some persons did, the supposed strategical position. Tactics and feeding the troops were enough for the first year, and criticisms based on any other supposition are quite beside the mark.

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It has been said by more than one great military writer that there is no such thing as the tactics of one arm. Admitting this, to a certain extent, there are yet some peculiarities of movement, whether acting in combination with other troops or not, which may fairly be called the tactics of a special arm. Regarding the movements from this point of view, let us think for a moment about the infantry—that most important and cheapest of the three arms—the only one which can go everywhere, and fight both stationary and in movement. Such at least is the supposed advantage of infantry over the other arms. But now come two most important questions:—Is the British line adapted to modern requirements? and if not, how should it be modified? There never was any hope of fairly raising these questions until the establishment of autumn manœuvres set all soldiers thinking about such things. Against the stiff British line may be set the opinions of such men as Colonel Hamley, Colonel Chesney, and Sir Garnet Wolseley, together with the whole body of continental officers. I am not aware of any officer of note who has undertaken to defend its suitability for modern warfare. It served Wellington's purpose; but in those days 200 yds. was a rather long range for infantry fire, and artillery could approach within the practical range of case, so that infantry in attacking had very limited distances to move over. Even then, it is remarkable that almost all Wellington's great victories were fought on the defensive, and consisted in the steady repulse of one attack after another till the enemy was exhausted. Let us turn back our minds to the days when, light and agile youths, we "did battalion drill" at the R.M. Academy. What anxiety we had when the last advance in line was ordered. How we hoped—prayed almost—that no unlucky pebble might come in the way, and cause us to be the human instrument of sending that inevitable shudder, wriggle, and break in the line which used to drive serjeants and officers to despair. With much training, we arrived at the possibility of "advancing in line," if the roller had done its work well; but oh, the frequent and agonising sense of failure! Now that ranges of

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† The lecturer here gave a rapid *vivâ voce* sketch of the manœuvres, which is omitted, because a fuller account by Captain Wolfe, R.A., has already appeared in the "Proceedings." (*Vide* Vol. VII. p. 496). In the course of his account, the lecturer mentioned incidentally that on the 16th, Staveley's division, though unsuccessful, was allowed to push on to Pirbright, because his supplies were to meet him there. No fault was found or suggested on this account.

small-arms are so much longer, and troops must advance over longer spaces, it is hardly too much to say that British infantry tactics must be almost confined to standing still or breaking through their habit of line formation. They must form some sort of column to advance, with power of rapid deployment. If it be granted—and all military writers now insist upon it as an axiom—that mobility is one of the chief requisites for success, the only question is how to gain such mobility. You all know that the Prussian battalion consists of a thousand men, divided into four companies, each company commanded by a mounted officer and formed into two divisions; that their fighting order is, speaking roughly, in column of these divisions at deploying intervals; that there are three ranks instead of our two, and that the third rank consists of skirmishers, who either swarm in front, or fill up the intervals, or form third divisions in rear at the moment of attack, as the necessity of the case may direct; so that the front of each column is only about forty files. Thus line can be formed almost instantly, to resist an attack, and, when in motion, the heads of columns can easily move with steadiness, conforming to the features of the ground. But, as I have already mentioned, during the latter part of the war, when the power of the chassepot had become known, the Prussian infantry worked in swarms, gathering in groups large or small wherever cover could be obtained, and pushing home a charge when an opportunity presented itself. On the 18th August, before this system was developed, the Prussian Guards attacked St. Privat in columns of such depth that there were on the whole front ten men to one pace of frontage. Nearly 6000 men fell in ten minutes, and the attack had to be discontinued till the French flank had been turned. The Austrians now fight, by regulation, in swarms at their manœuvres, and I am strongly of opinion that we must come to something of the same kind.

Every officer I spoke to, English or foreign, who knew war, remarked that the infantry at the manœuvres almost always gave ground too soon, instead of holding it to the last possible moment. May it not be believed that the officers in command knew the unwieldiness of the force they commanded, and were obliged to retire while they could do so in a leisurely manner? The error seemed to be that it was thought necessary to *stand erect* in line whenever the enemy approached closely; and this, if persisted in, was of course as wrong as yielding ground too early.

Perhaps it was for the same reason that the infantry clung closely to the batteries, and persisted in retiring whenever the guns did; forgetting that each arm should support the other, and that it is exactly when the guns are in motion that the infantry should hold its ground with the utmost tenacity. The Prussian officer whose opinion we value most was greatly struck by this, and seemed to consider the practice of yielding ground too easily so fatal, that the manœuvres would do more harm than good if it were persisted in. A kindred error, if it be so, was pointed out by one of the most famous of our visitors—the want of energy in attack. His words, as nearly as I can recollect them, were:—"The infantry should always keep pushing on. Some detachment, bolder or more fortunate than the rest, will get in somewhere; then the enemy becomes confused, and the rest of the line can advance." This is really the great secret of the Prussian infantry tactics, with their free column movements: isolated attacks, well supported, with confidence that each commander knows how to assist the rest.

But the discipline of our line regiments, and their grand, savage earnestness, when face to face, were splendid, and showed that the same material was there which called forth the remark—"The British infantry is the best in the world; happily there is not much of it." The slowness of their marches and heaviness of manœuvre will doubtless be corrected in future years, nor will they fail to give a good account of any enemy they may meet on the continent or on our own soil.

The powers and uses of cavalry form a fertile subject of dispute among soldiers, and we may safely say that they cannot be settled by peace manœuvres. The amount of men killed or wounded by this branch of the service is extremely small—so small that, were killing and wounding the main object of war, cavalry might be put out of the field altogether in these days of accurate and long-ranging small arms. But it has long been laid down as a maxim that it is not the number of men killed and wounded which beats an enemy, but the moral effect produced on the survivors. It is just this moral effect which cavalry are so well capable of producing; and it cannot be produced when infantry know that the cavaliers will not actually fall upon them. The teaching of the war of 1866 did not lead the Prussians to despise cavalry; on the contrary, from that time forward, greater attention than ever was bestowed on the equipment, horsing, and instruction of the mounted regiments. They are kept longer with the colours, as a rule, than the infantry, and every inducement is held out to them to re-enlist at the end of their term. In the late war, cavalry were frequently employed in large masses, especially to hold the enemy fast to a position while other troops were coming up. To this end they were sacrificed freely and ruthlessly, but the end was attained. This mode of using cavalry requires less practice than another, which hardly receives the attention it deserves. I mean the action of cavalry as the eyes and ears of an army; an almost better simile would be, the tentacles or feelers of an army. There are creatures whose whole sense seems to be concentrated in a number of filiments, fine as threads, with which they unceasingly sweep the water around them, not only guarding against the approach of their enemies, but causing a constant stream of prey-filled water to pass over the mouth of the animal. Such should be the action of cavalry. Now, at the late manœuvres there was nothing of this. A few men were occasionally thrown out on outpost duty, and more than once such men, being questioned, did not know in what direction to look for the enemy. I even saw one vidette with his back to the foe, and his face turned directly towards his own camp. How was this? Simply because of an omission which will render our manœuvres of only a tenth of their proper value, unless it be supplied. The men are not practised enough in these matters throughout the year. Knowledge is growing, and there are many first-rate cavalry officers, but it must grow more yet before all is satisfactory. We are accustomed to be proud of our cavalry, and with reason—in men, horses, and appearance they are splendid; but are they fit to be trusted at once, suddenly, with the duty of obtaining information for an English army and guarding against the enemy's obtaining information?

When France declared war against Prussia in 1870, ten thousand German cavalry were sent instantly to the frontier, without waiting for any army behind them. They swarmed over the whole country, patrolling every road, searching every wood and field, sometimes making dashes over the frontier,

appearing suddenly in the middle of the French army, breaking up a railway or carrying off a prisoner or two to give information. One regiment, the 5th Dragoons, was in daily feeling of the enemy from the 15th July to the 20th December, when I heard of their exploits; and from the 15th of November to the 20th December their horses were never but once unsaddled at night. This was in bitterly cold weather, with frost and snow on the ground. Such is the kind and the quality of work which we have a right to expect from our cavalry, but they must not begin to learn it at the autumn manœuvres. In Prussia, the cavalry recruits join in the autumn, and are practised throughout the winter in riding and foot drills. In spring the squadrons are formed, and drilled as squadrons; later in the year the squadrons are collected into regiments, and drilled accordingly, with constant study of outpost and intelligence duties. General Blumenthal told me that they find it necessary to place the men in various positions, ordering them to watch in a certain direction; they are then visited frequently, and if they are found turned away from their proper outlook, they are severely punished. Thus it comes to pass that, when the autumn manœuvres take place, all the cavalry, including the recruits of the year before, are ready to undertake outpost duties in the face of an enemy.

This seems to be an opportunity for calling attention to a most serious want in the British military organisation. We have no intelligence department, nor even any plan for creating one instantly in case of war. During the great American civil war, the Prussian authorities gave leave to certain officers to quit the service temporarily and go to America, entirely ignored by their own Government; but they understood that if they returned with useful information it would be considered as a fact greatly to their credit, and sure to result in advantage to themselves. No questions would be asked as to the position they assumed to acquire the information. Before 1866, the mountain passes of the frontier, the plains of Bohemia, Moravia, and Hungary were studied with such care by Prussian officers, that the fords on every river were known, and even the length of timbers required to construct bridges, should the permanent ones be broken down by the enemy. In the interval between 1866 and 1870, the whole of France, or at least the more important parts of it, were visited by German travellers—actually Prussian officers—who corrected the French maps, and made plans and sections of all the fortresses. I myself possess some of those which they made of the forts of Paris; and upon these plans and sections were based the calculations made by the artillery as to the curvature of the shot's path necessary to reach the foot of the escarps over the crest of the glacis.

So little value has been attached in England to work like this, that almost all information voluntarily acquired used to be ignored, and the military attachés at embassies have been, in moments of temporary necessity, called upon to give speedy information as to matters upon which they had long before written full and careful reports. Now, is this worthy of a practical people like the English? On account of our exclusiveness, our love of gain, and our desire for peace, foreigners delight in calling England "the modern Venice." We think we are something better; but as we seek many of the same objects, let us not forget the wise provision which the Venetians made for being perfectly informed on all foreign military and political subjects. It could not be bad, even for trade, to have the most

perfect information and the most perfect maps of every country, and if it came to a foreign war, every officer ought to be provided at the country's expense with an excellent map of the theatre of operations. The Prussians did this, with their limited military expenditure; why should not we do it with our large one?

The organisation of a war intelligence department should at least be sketched out, and there would be plenty of work even now for the officers composing it, who might try their prentice hands upon England to begin with. The maps of the district comprised within the manœuvres this year were so often wrong in roads, woods, and enclosures, that it was quite impossible to ride by them with any confidence.

Artillery and Transport.

The first remark to be made with regard to the artillery at the late manœuvres is, that there was no clear distinction made between divisional and reserve artillery. In all armies taking the field, so far as I am aware, this distinction is invariably made; indeed, in large armies there are usually two reserves—the reserve artillery of each corps, and the reserve of the army, held more closely under the hand of the general. Curiously enough, in some of the orders as to detail of troops in the manœuvres, the whole of the artillery was set down as reserve. It was only after the second division was broken up and divided between the other divisions, and not while there were actually two divisions in one army, that something like a distinction between divisional, or brigade, and reserve artillery appeared to be made. It is an old complaint that few generals know how to make best use of their artillery. Even Napoleon—who was perhaps the greatest master in handling the three arms that Europe has produced—himself an artilleryman, used to give much of the management of the guns to his trusted artillery generals. Until this year, it has been the custom in the English service to place the batteries in line with the infantry and keep them there, in fatal rejection of the knowledge that just where the fire of infantry ceases to be effective that of rifled guns only begins to be valuable; and, furthermore, that to place field batteries within practical range of the enemy's infantry, is to make certain that, win or lose, the guns will have to stay there, for the horses must be killed. There are few who know how tenaciously this old system was adhered to, or how indignant were many superior and much respected officers of renowned names when the contrary opinion began to be advocated. But, in England at least, truth is all-powerful, and will sooner or later prevail over prejudice. There is no one of the acts of His Royal Highness the Commander-in-Chief for which artillerymen—and not only they, but the whole army—have such reason to be grateful, as the order which freed the English field artillery for ever from the trammels in which it had hitherto been bound, and raised it to the splendid position of honour and responsibility which it now occupies. With that responsibility the men may surely be trusted who showed battery after battery in such perfect order as to draw forth praise from all beholders. When a future writer pens the history of the English Royal Artillery, he will be able to say that in the reign of the Duke of Cambridge the greatest advance was made in the progress of artillery tactics since the time of Frederick the Great.

For some time to come, the new system will need plenty of tact and temper for its smooth working. Artillery captains and colonels will not find it easy to be certain what are the general's plans, therefore it will be difficult to conform to them in all cases; but, in time, everybody will fall into the new ways, and wonder how the old ones could have existed so long.

In the presence of so many artillerymen more worthy to be heard than myself, it is difficult to remark on anything which seemed wrong with the artillery at the manœuvres, especially as so much went right. What I have to say is not merely my own opinion, but embodies the views of many brother officers whom I have consulted.

First. It seemed to many officers that the guns moved too frequently, thereby losing valuable time, instead of taking up positions and remaining there as long as possible. Perhaps this arose partly from the old habit of keeping infantry and guns together, so that if the guns moved to a good position in rear of their former one, the infantry thought it necessary to follow; then, up came the enemy's skirmishers, and the guns had to retire again. An officer of horse artillery speaks of this in a letter received from him only yesterday.

Secondly. At the manœuvres there was hardly ever a concentration of fire upon part of the enemy's line, to make a hole there for the infantry to get in at. On the day of the attack on the Chobham entrenchments, the salient angle of the defenders was a weak spot, and it would have been easy to place guns so that if they missed the angle they might enfilade either face. Here was exactly the case when reserve artillery might have been most valuable. But of what should such reserve artillery consist? Clearly of horse artillery, for rapidity of movement, and batteries of that magnificent gun, the new 16-pr., which need not approach closely, but take up positions wherever they can be found well sheltered.

A third point which seems to need some attention, is the part to be taken by the wagons. With my own battery of 12-prs., I find that three men mounted on each gun limber can be carried over very rough ground, even banks and ditches, and can work the pieces quite fast enough for all practical purposes. If the wagons remain 500, or even 1000 yds. behind, they are sure to find shelter somewhere, and can be called up soon enough when wanted. The charge of them is a post requiring much knowledge and eye for country; no second captain need be ashamed of such a duty.

Next to the guns themselves, the horses need most care; those grand gun-teams must be preserved in every possible way. It struck some officers present at the manœuvres, that the limbers adhered somewhat too strictly to the drill-ground practice of standing just behind the pieces in action. It often happens that, by going a few yards to the rear without reversing, the limbers themselves are within easy reach, while the teams are less exposed. Of course the guns must be put under cover when possible, not only to make the chance of striking them small, but to throw every difficulty in the way of the enemy's ascertaining whether his range is good. If a whole battery is concentrated in one place, the enemy can easily see if he has hit horses or men; he is puzzled if the damage he does is concealed. In this part of artillery tactics, the Prussians—taught constantly to seek cover—are most clever.

Lastly. All batteries should be furnished with range-finders.

The remarks now made are offered with the utmost diffidence, and only because they are supported by the opinion of first-rate artillerymen, both at home and abroad. The art of handling guns is not to be picked up suddenly; it must be learned steadily, step by step, in the drill season. Autumn manœuvres will only test and improve knowledge already obtained. Each captain of a battery has his own choice of drills. There are some, at any rate, who hold that a systematic course should be pursued every year, beginning with gun drills and foot parades, going on to driving drill, battery and brigade movements, then selection of ground and concealment of guns, men, and horses. Later should come manœuvres with the three arms in small bodies, with plenty of practice in attack and defence of defiles or villages, passage of rivers, and other exigencies likely to occur in war, but hitherto not much taught except in theory. Finally, autumn manœuvres, to test knowledge on a large scale.

In equipment, care of horses, driving, riding, and drills of all sorts, no foreign artillery can approach that of England. In knowledge of minor tactics we have yet some progress to make. The autumn manœuvres have given the impetus required, especially now that we are free to act. Next year there can be little doubt that English artillery officers will display a knowledge of tactics equal to that of any artillerymen in the world.

Transport.

We now come to the question of transport and supply generally. In this branch of the knowledge of war it must be confessed that we are now, as we have always been at the commencement of a campaign, decidedly backward. The ordinary supply of garrisons gives no clue whatever to that of an army in the field, and it was only when we came to try it last September that we discovered how difficult and complicated a task it is. Like the "Intelligence Department," that of supply cannot be suddenly formed; it must grow. Its duties must be well known, and all circumstances provided for.

The organisation of the Prussian "*Etappen* Department" is a wonder in itself, and it is startling to find how inextricably it is interwoven with the organisation of the fighting branches. For instance, Prussian cavalry regiments have no dismounted men. If more men than horses are killed, the spare animals are placed in charge of the *Etappen* Department; if more horses than men are killed or broken down, the dismounted troopers are supplied with animals from the *Etappen* Department.

Permit me to quote part of a letter written from Orleans last winter:—

"Any number of such corps can be formed into a field army, but each one of them retains its identity under all circumstances. Whether a corps be at home or on a foreign soil, it is watched with affectionate eyes by the people of a certain district in Germany. Their hopes go with it and their fears. Its successes cause rejoicings throughout a whole division of the Fatherland. If it suffers severely, large towns and great country populations are clad in mourning. From this organisation it follows that no effort will be spared to keep it well supplied with all necessaries, and the system of supply is such that the stores of food and clothing collected in each district go to its own *corps d'armée*. But no corps can be disconnected from the field army of which it forms a part for the moment, so it is

necessary that the supply system shall be based on two principles—first, that each corps be supplied, as far as may be, from its own district; and second, that the supply of each field army, no matter how many corps it may contain, shall be under the direction of one chief. The combination is secured thus :—

"The supply of a whole field army is placed in charge of a field officer holding the rank and position of a General of Division. His department is called the *Etappen* Department, or department of the line of communications. The general who takes charge of the whole supply of an army in the field is called the *Etappen* Inspector. His duties and responsibilities are numerous, and second to none in importance. It was the difference between the organisation of the French and Prussian armies in the two points of district corps and *Etappen* arrangements, which placed superior Prussian forces in the field while the French were still hurriedly collecting troops from the whole country, and sending men from Strasburg to their depôts in the south of France to get their arms and uniform, though the regiment to which they belonged was actually assembling near Strasburg itself.

"The *Etappen* Inspector for a field army has attached to him a chief of the staff, and officers representing respectively the artillery, engineers, intendant, medical, field post, telegraph, and railway departments. All the troops detailed for defence of the line of communications are placed under his orders, and have nothing to do with the army in the field except to watch the ways by which it has come, over which it must return, and along which its supply of life blood must flow. So an army advancing into an enemy's country does not necessarily diminish as it proceeds, only the further it marches the more soldiers follow it from Germany to be distributed along the railway or roads forming its line of communications. In case of retreat, it gathers like a snowball as it rolls along.

"The artillery officer is responsible for all artillery *matériel*, whether guns, ammunition, or stores, and for the ammunition of the infantry. The engineer has to look after all means for digging trenches, &c., including everything required by his own branch of the service. The Surgeon-General and all the other officers detailed above, have the charge and responsibility of supplying whatever may be wanted by the medical officers in the field. The great railway or road leading from the base from which the army has originally marched is entirely in charge of the *Etappen* Inspector and his assistants, and if anything goes wrong with it there can be no doubt where the responsibility lies. But his charge begins with this main line of road or railway, or both together, side by side, and ends about one, two, or three days' march, according to circumstances, behind the field army. It is the business of the districts to send stores to the main line near its commencement, and that of the corps themselves to receive the stores from the *Etappen* Inspector's last station, or station nearest to them, and to distribute them.

"Each corps in the field has an *Etappen* Department, with transport of its own, and far away in its German district, hands are busy collecting supplies, packing them, and forwarding them to the station appointed, generally the nearest, on the main line, where the *Etappen* Inspector takes charge of them.

"Whatever is collected and packed in a district is marked as belonging to its own corps, though all rules must be understood as liable to exception; and there can be no doubt that, in case of need, one corps would not be allowed to overflow while another starved. At intervals along the road, depôts are established to feed the army with stores of all sorts, even if a temporary accident should occur on the line and the regular flow be cut off. The trains are made up of carriages conveying various articles. Each carriage has its way-bill or paper stating its contents, and their destination. If one is detained some time at a station on the road, its way-bill remains with the *Etappen* officer at that station. He has given a receipt for it, and is responsible until it leaves his hands again.

"Generally speaking, all meat is made to carry itself on its own legs, and much

of the provisions consumed by the army is drawn from the surrounding French territory. That is the business of the Intendant officers, both of the corps themselves and of the *Etappen* Department all along the line.

"With respect to reinforcements coming up along the *Etappen* railways and roads, the machine works perfectly. The officer at a station hears by telegraph that he is to expect 500 men, we will say, at a certain hour, when they are to dine or sleep and be forwarded. He provides dinners or billets for them, as the case may be, and when he has performed his part, sends them forward. But, once off the great roads, supply becomes more difficult, and corps on the march or actually fighting cannot always be fed with certainty. What remains to be done, over and above the Prussian system, is to make each man carry his own depôt of food sufficient for three or four days at least, in a form not liable to damage. This small store should not be used except in case of necessity, and should be made as completely a part of the soldier's equipment as his ammunition now is. An army always carrying provisions for six days would be movable to a degree not even yet attained, and it seems to me very extraordinary that soldiers are obliged to carry extra boots and clothes, books even (every German soldier carries a hymn-book), and yet be dependent on his provision columns for food. Certainly, the present system has one advantage—the men are held bound to their battalions by the knowledge that if they once fall out of the general harmony they are extremely likely to starve."

Here is the system of a successful army, and the details of it are practised at the autumn manœuvres in North Germany. It is based upon the principle that the fighting divisions have enough to do to fight, and that it is a mistake to spread out the army along a line of communications, as we did in Abyssinia, so that the further the army enters into an enemy's country the smaller it becomes for fighting purposes.

It is impossible to test an organisation of this kind in any other way than by giving it an *advancing* army to feed, as may be done at the manœuvres; but the same thing can be practised on a small scale by the movement of small bodies of troops during the summer. So unlike is our present system to this, that when my battery marched about fourteen miles to camp for practice this summer, I was obliged to send back and fetch forage for the horses every day. No wonder that the supply during the manœuvres was sometimes unsatisfactory.

Lessons and Suggestions.

The manœuvres being instituted for the purpose of instruction, as well as to test our military system, what lessons have we learned?

First, we have learned the necessity for, and value of, such manœuvres.

Secondly, that they are possible and even popular in England; that the military spirit of the country is not dead, but only dormant, waiting the moment when our interest shall compel us to war, or some unbearable insult shall cause the blood of Englishmen to inflame their brows with mingled feelings of rage and shame.

Thirdly, that the whole army is somewhat deficient in knowledge of minor tactics. Many instances of such defective knowledge might be cited, but it is wiser to refrain, since the want is not now denied.

Fourthly, that we are very backward in organisation of such necessary departments as those of intelligence and supply, as well as in arrangements for smooth working between the staff and the supply departments.

Lastly, that what there is of our army is splendid material, needing only a little more organisation and a few such manœuvres as we shall undoubtedly have now, to put to silence all the ignorant talkers who have said that England's power of making her voice respected is over. We may well ask, what nation would think lightly of a British contingent of 100,000 men, with the whole country, its wealth and energy, behind them? Read every day in the papers the astonished utterances of foreigners, who find the entire nation, Republicans and all, gathered in heart round the bedside of their Prince, watching the ebb and flow of life, or clamouring at the gates of heaven in prayer for the recovery of the heir to the throne. Henceforth we may be certain that the nation *can* pull together, both in peace and in war.

The suggestions which I would venture to put forth for discussion by those wiser than myself are:—

1st. That future manœuvres should only be the completion and crown of a systematic plan of drills and instruction in minor tactics carried on through the year, commencing with mere parade work, and gradually ascending through perfect drill of units; then combination of the three arms in small bodies, commanded by comparatively junior officers, under the eye of the generals; then brigade drills, where possible, before concentration into divisions—the divisions themselves to be drilled and manœuvred before acting against each other; outpost duties to be performed as often as possible. Such a plan as this would free the hands of the generals very much, everything being prepared for them when autumn comes, instead of many things having to be taught.

2nd. The system of transport and supply should be placed on a more comprehensive basis, and an attempt made to assimilate the supply of the troops throughout the year with that of an army in the field. Never again should we be put to such shifts as hiring the crazy vehicles, with their miserable horses and undisciplined drivers, which checked every provision column in September, and made freedom of manœuvre quite impossible.

3rd. To practice the supply departments fairly, a division should march 100 miles supplied from its base of operations, and the march should be not too near London.

4th. Every general commanding a division should have a chief of the staff, who should be charged with the responsibility that all orders are properly carried out.

5th. The infantry must learn that their place is not alongside of rifled field guns, but that the latter may often be advantageously placed as much as 1000 yds. distant. The foot soldiers must show more audacity in pressing forward, and less readiness to retire. Brave they would be in real battle, but the force of habit is almost irresistible. Consider how a month or two in the trenches before a fortress spoils soldiers for the field.

6th. Mobility being of the greatest value, some modification at least of the stiff British line is imperative. Men must change with circumstances.

7th. Cavalry should have more systematic practice of outpost and patrol duties; officers and men being constantly required to bring in information.

8th. Since so much responsibility has been lately given to artillerymen, tactical studies are absolutely necessary. All the minor operations of war should be practised throughout the year, so that there may be proficiency in

the autumn. Having won golden opinions this season, we must take care to keep them by further progress.

These are, I believe, the main points to which attention is requisite, and there can be no doubt that attention will be given to them, for they are not the mere crotchets of a few individuals.

It is said that "the gods blind those whom they wish to destroy." Let us give the converse, and say that "Heaven opens the eyes of those whom it wishes to favour." The new and extraordinary attention now paid in England to the art of war, is unlocking the fountains of knowledge at a prodigious rate. The progress already made is marvellous. Is it not possible that we may be unconsciously preparing ourselves for a not far distant day, when our country may have to draw the sword for the principle of moderate liberty—when officers and men shall march forward in perfect training and mutual confidence, and our banners once more be flung out to the cry of "St. George for Merry England!"

General ADYE, at the close of the lecture, said they should be pleased to hear any officer who wished to make observations on the highly interesting lecture they had heard.

Colonel DOMVILLE, R.A., said he listened with much pleasure to the very able lecture that Captain Brackenbury had been kind enough to deliver. The remarks on the tactics of the artillery were of much weight, and the criticisms generally were characterised by judgment and fairness. He had not intended or desired to make any observations thereon; but as discussion was invited by the Chairman, and it appeared to be expected that he, as the colonel in command of the artillery attached to one of the *corps d'armée* engaged in the manœuvres, should make some comment on the lecture, he would trouble them with a few words. Firstly, as to the relations of the commanding officers of artillery with general officers in command of the troops, and the independence of movement of batteries as referred to in the general order to which allusion had been made by the lecturer, he could only say that, so far as he was concerned, the general officer had invariably conferred with him on every occasion, whether in making his arrangements for the distribution of the troops previous to each day's operations, or with respect to the dispositions of the batteries at any critical period during the movements which rendered any change of plan necessary. Any opinions he had submitted had invariably been received with the greatest consideration, and, of course in due subordination to the general's own plan of operations, had been acted upon. He could not speak too highly of the zeal and ability of the lieut.-colonels and the captains of batteries under his orders, nor of the hearty co-operation afforded him, and the earnest desire which had been shown by officers of all ranks to effectually carry out his orders and wishes. Thus, keeping in mind the high state of efficiency of the batteries, which could not but have been obvious to all there present, he must be fully prepared to take on himself the entire responsibility for any errors and shortcomings or mistakes that might have been committed by the artillery under his command.

As to the desirability of keeping in hand and under the immediate control of the commanding officer of artillery a sufficient reserve to meet such eventualities as might occur, which the lecturer appeared to suppose had not been done, this was a misapprehension on his part; for in each day's dispositions, when the number of batteries present admitted of it, a reserve had always been detailed, one battery

only being attached to each brigadier-general's force, which force might be taken (from the small number of troops altogether engaged) to represent a division, and such battery the divisional artillery; and when the cavalry were called upon to act *en masse*, one battery of horse artillery was attached to the cavalry brigade, but at other times kept with the reserve, which consisted of the two remaining batteries of field and one other battery of horse artillery. This reserve was held entirely at the disposal of the commanding officer of artillery, to be brought to bear on any important point that the general officer in command might deem necessary. The lecturer mentioned the attack on the entrenchments at the Chobham Ridges as an occasion when it would have seemed especially desirable that this reserve should be brought into play. He was doubtless correct. Why was it not? Simply that on that morning the attacking force had been deprived of the whole of the reserve, and the three batteries composing it handed over to the enemy and placed in his entrenchments. Now, to anyone who witnessed the heavy fire of the previous day's operations, the comparative weakness of the artillery fire on an occasion when artillery seemed peculiarly and especially needed, was probably remarkable; but as these eighteen guns had been taken from one side and added to the other, it must be seen that there was no help for it; for, in fact, every available gun was brought to bear—the divisional artillery being removed, as it were, from the immediate control of the brigadier-generals, and the whole, under the orders of the general in command, concentrated on the chief point of attack. And I may remark, when speaking of concentration, that whilst the batteries were separated and placed under the best cover available, nearly the whole fire was concentrated on the salient entrenchment.

It was said that the batteries moved too often. Such might seem to be the case. Now, in actual warfare, if an artillery fire was opened upon troops, its effects would at once be felt, and if the bodies under fire should be in consequence removed to a greater distance, yet within range of the guns, it would doubtless be an easy matter to still make the artillery fire felt, simply by increasing or diminishing the elevation of the gun, without moving the battery; but in these peace operations it was found almost impossible to persuade the supposed enemy that he was being actually annihilated when fired at from a distance of perhaps 2000 yds. or upwards. Had it been practicable to have burst a few rounds of shrapnel amongst them, the sensation would have been somewhat different. It thus became necessary, in order to produce an effect, to keep the guns in more immediate proximity to the troops attacked, and thus, consequently, to move as they moved—at any rate, much more frequently than was in accordance with the received rules of artillery tactics. This difficulty had been obvious on more than one occasion, and more peculiarly so when batteries had been placed with much judgment in admirably selected positions, where nothing but the muzzles of the guns was visible, and that only at the moment of firing. This was the case on the first attack on the Fox Hills, when several regiments of infantry and two batteries of artillery were drawn up in, as they supposed, an entirely sheltered spot, and hidden by thick woods in their front—waiting for nearly two hours, until broken down bridges were supposed to be repaired before they could cross a railway. The enemy had, during the whole of this time, a battery of heavy guns firing at them from a wooded knoll about 1800 yds. distant. Well, why did the general not remove his troops under cover? Simply because he did not suppose the fire was directed at them; for he knew that the remainder of the force was proceeding by another road to take the position in flank, and supposed the fire was directed at them. On another occasion, it was not until an umpire of high rank had been found, and been urged to go into a battery which had been peculiarly well placed behind a railway embankment, and, as on the former occasion, entirely hidden, that it was allowed that a certain regiment which had been holding its ground firmly was knocked to pieces, and was ordered to move away; the umpire only being able to see, when he got into the

battery, that every gun was bearing on the opposing force, which was massed in column and in reserve behind a line of skirmishers, and, as before, quite unconscious of the artillery fire. These are doubtless *contre-temps* which must occur in mimic warfare, and more especially in a wooded, enclosed, and hilly country like that around Aldershot.

There could be no doubt of the great value of these autumn manœuvres. Officers of all ranks had learnt much from them; but still the lessons were not lessons such as were to be learnt in actual warfare. Much must be taken for granted; and in order to play the game with success, it was necessary that precise rules should be laid down for the observance, not only of the troops engaged, but equally so for the guidance of the umpire staff, who were appointed to judge of the value of the movements, and who were to decide whether assailants or defenders had got the best of an encounter.

Colonel MILWARD, R.A., said he agreed entirely with the remarks made by Captain Brackenbury as to the necessity in future warfare of retaining a very large proportion of the artillery in reserve, available for concentration on any particular point, and more readily at the disposition of the general commanding than if distributed among brigades. The fact of the batteries being thus held in reserve, however, necessitates extreme mobility to make them thoroughly available; as they will be required frequently to move rapidly for long distances, to meet sudden emergencies. For such purposes horse artillery is the most suitable, and there is no doubt that batteries of that arm will be largely required for the reserves. It therefore appeared to him that every effort should be made to attain great mobility for batteries of field artillery, and the question is worth serious consideration whether the proportion of horse to field batteries in the British service is nearly sufficient.

Colonel GORDON, C.B., R.A., then remarked:—With reference to the second subject suggested for discussion by Captain Brackenbury, he could not help thinking the supply department were not so much to blame as it had been supposed. At the commencement of the lecture, Captain Brackenbury mentioned that on the 15th, after the affair at the Hog's Back, the supplies of the attacking force were at Pirbright, behind the position occupied by the defending force; it was therefore necessary for the latter to fall back in order that the former might obtain their supplies. Again, it had been stated in the "Times" that on the 14th 2000 men were ordered to join the 2nd and 3rd Divisions at Frensham, and camp equipage and supplies were prepared for them there; on the 15th this arrangement was altered, and the 2000 men were ordered to Chobham, where similar preparations were made. On the 16th 1100 men were sent to Chobham, and the remainder were dropped in the afternoon at Brookwood Station, as the railway authorities were unable to carry them on. At Brookwood no preparations had been made to receive them, and it not being possible to convey tents and rations across the heath in the dark, they had to lie down in the open, supperless. Another account, in the same paper, stated that half a cavalry regiment had been without rations for one day; but it had been since ascertained that rations had been furnished to the regiment by the supply department, but that half of the regiment having been sent away on outpost duty, they did not receive their rations; and he thought this might be some one else's fault but that of the Control. He would suggest that, while no doubt several mistakes occurred, all the blame might not be due to the supply department, but some should be borne by the Q.-M.-General's Department*—*using the word in the largest sense.*

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* Colonel Gordon much regrets that the expression above was made use of, as it was misunderstood. He hoped that it would have been understood by his brother officers as embracing all officers on whom devolved the duties of making arrangements for moving troops, either in considerable bodies or for small bodies detailed for the day on outpost duty.

Colonel DOMVILLE said he did not hear any complaints made, except on such matters as might be easily rectified on future occasions. He considered the supply department worked most zealously, and was handled wonderfully well, especially considering they had only so recently been re-organised.

Lieut.-Colonel YOUNG, R.A., while thanking Captain Brackenbury for his able and interesting lecture, said there was one thing which he must find fault with, and that was that the lecturer adopted the prevailing fashion of the day by thinking everything Prussian must be right. Because the Prussians had succeeded in the wars of 1866 and 1870 seemed to him no reason why we should adopt everything Prussian. He did not think their company column was altogether the right formation; as far as he knew, they had never seen it under a heavy reverse. He believed the unit to be too small, and that there would be want of cohesion between the columns, which on a sudden retreat would be fatal. Their system of skirmishing seemed to him also defective; being a weak line, and liable to annihilation by good shrapnel fire. Not having had the experience of Captain Brackenbury in the seeing the Prussian system in the field, he made these remarks with diffidence. (Cheers.)

Colonel FIELD, R.A., said Colonel Milward's remarks were of great moment. He would ask Captain Brackenbury whether he advocated concentration of guns or concentration of fire.

Captain BRACKENBURY said :—Alluding to the artillery reserve of field batteries mentioned by Colonel Domville, he believed it was not named in orders.

Colonel DOMVILLE.—Not in general orders, of course, but in the orders of the division or *corps d'armée* to which he was attached during the actual operations.

Captain BRACKENBURY continued :—He had read in the "Times," before he went to Aldershot, that all the artillery was named as reserve except the horse artillery attached to cavalry brigades. He was greatly astonished at what he supposed to be the blunder of a correspondent, and, upon making enquiries, found that all the artillery had been in orders placed in reserve, except the horse artillery. Colonel Milward's remarks were quite true—mobility was required for artillery; but how was that mobility to be attained? He should certainly like to have more horse artillery; but they had more now than they ever had, and he doubted whether the Government seemed disposed to grant anything so expensive as an increase of the horse artillery. The new gun—the 16-pr.—lately introduced for field batteries, was a weapon of great power, suitable for reserve. The 12-pr. batteries must be made as movable as possible. With reference to the remarks of Colonel Gordon, he must say he had endeavoured to guard himself against being misunderstood to make any attack on the supply departments. He had nothing to say against the officers of the supply departments; their energy was untiring and their zeal great. They did well, considering that they had no experience in such work, and it is not the fault of a young department that it has not sufficient experience. Everything that had been stated only went to show the necessity of both Staff and Control learning to act together in matters of supply —(cheers)—and the existing want of practice in the supply of an army in the field. With Colonel Young, he was far from thinking everything Prussian right, and did not wish to adopt all their ideas, only such as were good and suitable. (Hear, hear.) There is no reason why we should not devise a better system than that of company columns, but we must devise something. What the British line used to be to the continental heavy column, the present "swarm" formation with strong reserves seems to be to the British line. The steady, firm character of the British soldier is admirably adapted to the swarm formation. He wished it to be understood that he advocated the very opposite of heavy columns—something lighter, even, and requiring more courage than the line. The Prussians, however,

in their company column formation, have often suffered temporary checks, grave enough to oblige them to retire. The fact that they have eventually won almost every battle they have fought, is hardly an argument to be quoted against their system. After the frightful loss of life before St. Privat on the 18th August, the Guards retired in order, and attacked again, an hour and a quarter later, with success, when the Saxons had turned the French right. In reply to Colonel Field, he advocated the concentration of fire, and, as far as possible, the separation of guns.

General ADYE said:—He felt sure that all military men would agree in the advantages likely to arise from the manœuvres of large bodies of men, such as were carried out in the autumn manœuvres. The very concentration of thirty or forty thousand men of all arms—the feeding, moving, and arranging them in order of battle, afford valuable lessons, not only to young soldiers, but to the staff and higher officers also. So far as relates to our own arm, it is gratifying to feel that not only the experienced officers of our own army, but also those of the great continental powers, spoke in favourable terms of our *personnel*, our *matériel*, and also of the manner in which the batteries were handled. He thought we were rather apt, perhaps, to overload ourselves with equipments, not of the first necessity, and that we should bear in mind that the gun and its due supply of ammunition are the vital points for consideration. We also are in the habit of moving the position of our batteries rather too often in action. This, however, is partially due to the fact that we are fighting sham battles, and not real ones, and would rectify itself on service.

Speaking of the manœuvres generally, he pointed out that in some respects we had to encounter even greater difficulties than we should have in real war. In the latter case, the roads, railways, and telegraphs would all be at our disposal; we should take possession of the towns and villages, and thus obtain shelter; the food, forage, fuel, and means of transport of the country would be available for our use. The Prussians, in their autumn manœuvres, do take military possession of the district far more completely than we do; that is, their men are billetted in the villages, or they lie in the open, and any wagons they may require for baggage or sick are obtained by requisition on the spot. This facilitates their movements and enables them to dispense with tents. With us, we moved between thirty and forty thousand men without disturbing the rights and privileges of the inhabitants, or without in any great degree availing ourselves of the local resources. It was therefore necessary to provide the whole force with camp equipage, and with hospital arrangements. Many thousands of waterproof sheets were issued, for the men to lie on. The men were also, for the most part, supplied with fresh bread and fresh meat, and, owing to the cattle disease, the animals could not be driven across the country and follow the troops. The consequences were that we had a large number of wagons, of ambulances, and of water carts following and encumbering the troops. All these circumstances added to the difficulties and to the cost of the operation. He should like to see a somewhat sturdier and a simpler campaign. He should like to see more self-sacrifice on the part of the inhabitants. It is difficult to conduct even peace campaigns, and to concentrate great bodies of men, without in some degree taking military possession of the country. The troops engaged should dispense with all superfluities. War is a rough trade, and if armies are to move quickly the men must be ready for hard marching, coarse, badly-cooked food, and to lie out, if need be, in ploughed fields.

We have heard much lately of military organisation and administration. These are essential, but there is something on which success depends even higher than they, and that is national character. Our ancestors were hardy, bold, and enterprising. By the exercise of these fine military virtues we have founded colonies,

and won a great empire in the East. It is for us to take care that, amidst the luxuries, the pleasures, and the accumulated riches of these days, we do not become enervated, lazy, and degenerate. If we preserve our national character as of old, we may feel secure, and we may rely on it that the necessary organisation will readily follow.

General ADYE concluded by expressing to Captain Brackenbury the thanks of the meeting for his exceedingly interesting lecture. The meeting then broke up.

December 19, 1871.

[I would venture to suggest that the umpires at the manœuvres should all have assistants attached to them, who could gallop off at any time to ascertain such facts as upon what object artillery were firing, carry word that artillery claimed to be destroying a column, &c. In fact, the assistant umpires might be used in considerable numbers, to keep the chief umpires informed, and enable them to direct their attention to the main features of the manœuvres.—C. B. B. *Ipswich*, 8. 3. 72.]

"KRIEGS SPIEL," OR "GAME OF WAR."

BY

CAPTAIN F. C. H. CLARKE, R.A.

(*Extracted from "Colburn's United Service Magazine" for Feb.* 1872).

The rapid and remarkable successes achieved by the Prussians in recent wars, have naturally led people to enquire into the causes which have contributed to produce such results.

Leaving out of consideration causes of a non-military nature, into which it would be foreign to our subject to enter, it requires no argument to show that those brilliant results have been mainly due to the care which has been bestowed in perfecting the mechanism of that great military machine—the Prussian army.

Apart from the excellent administration which could throw an army of half a million of men on the frontier within the space of a few days, fully equipped and ready to take the initiative, which, although a fruitful theme for investigation, is one with which we are not now concerned, there remains the *tactical success* of that army on the battle-field.

With this latter, which after all is the first object in war, our present subject is closely connected.

In Prussia, the instruction of officers and men in the art of war is conducted on the principle *that they should practice in peace what they may have to do in war;* that is to say, whether in the field, as at the autumn manœuvres, or in the closet, at the "Kriegs Spiel," the aim is to represent to the mind of those taking part, a picture approximating as far as possible to that of real war.

The value attached by our military authorities to these practical methods of instruction, is shown by the fact that we have adopted into our service the system of autumn manœuvres, and are about to introduce the "Kriegs Spiel" as a means of instruction in our garrisons.

For the benefit of those who have not seen the game played, the "Kriegs Spiel" may be defined as the representation of some definite operation of war on a plan drawn to a large scale, upon which, instead of the troops, certain movable signs representing them are made use of.

It was first thought of more than half a century ago by a civilian with military tastes, whose hobby it was to follow the movements in a campaign or in a battle on a large map—in much the same way that

people used the flag-pins last year in tracing from day to day the positions of the various armies in France; but the idea of extending this method to the *devising* of *games of war* was worked out by his son—a military officer of considerable talent—Baron von Reiswitz, then a lieutenant in the Artillery of the Guard, and subsequently an aide-de-camp to Prince Augustus. This officer, after giving promising signs of a great career, was unfortunately cut off by death at an early age, but not before he had developed his system, and had had the honour of explaining it at several foreign courts.

Amongst the warmest enthusiasts in the game, when Reiswitz first introduced it to his brother officers, may be mentioned the three following distinguished soldiers: von Griesheim, then a lieutenant in the 2nd Foot Guards, the author of the excellent work on Tactics which bears his name; von Decker, an officer of considerable reputation, who, as Commandant of the Artillery of the Guard, took considerable pains in promoting the success of the game among his officers; and thirdly, von Müffling, a well-known officer of the Prussian staff.

Reiswitz took his invention to Russia, where it was received with great favour by the Emperor Nicholas, and at first by the military authorities, and although the Emperor remained a very warm partisan of the game, the military authorities, for some reason or other, did not seem eager to adopt it. It is said that the decline of its popularity was due to the following incident. It so happened that Reiswitz, when in that country, introduced, in his position as instructor, a series of games on the memorable ground of 1813, among which the battle of "Gross Görschen," better known under its French title of Lützen, came on the *tapis*.

It will be remembered that in that battle the French moving from Erfurt had arrived in the vicinity of Leipsic. The allies from their position near Leipsic, prepared to adopt the plan proposed by the Prussian General Scharnhorst—viz., to fall unawares on the flank of the French while on the march, using their cavalry, in which they were very superior, to prevent the French columns from coming to the support of one another. This bold scheme failed in the execution, owing to the faulty dispositions of the Russian staff, under Wittgenstein. The columns moving to the attack crossed one another, delaying the march, and instead of striking the enemy's flank soon after daybreak, they did not come into line until nearly noon.

The intention was discovered by Napoleon, and the battle ended at nightfall by the retreat of the allies.

In the game at which Reiswitz was presiding, the officer acting as commander of the allied forces adopted Scharnhorst's leading idea, at the same time avoiding the mistakes of Wittgenstein, and just as the game, by the turn of events, placed the French force in a very unfavourable position, a Russian officer of high rank entered the room. This officer was Diebitsch, who afterwards became Field-Marshal and Commander of the Russian Forces in the Polish campaign in 1831. Diebitsch, although a warm supporter of the game, was a personal friend and Chief of the Staff to General Wittgenstein.

It is said that he was not so much displeased at the turn of the game,

but he seemed to think that, under some circumstances, the "Kriegs Spiel" might conduce to the weakening of military authority.

In reality, one of the greatest advantages of the game is the manifestation of errors, which, however unpleasant to personal feelings, ought never to be allowed to stand in the way of the furtherance of the true principles of the art of war. To be blind to one's own faults, as is well known, was one of the causes of the disasters which befel the French army last year.

With such men to promote it after poor Reiswitz's death, as those three distinguished officers, it is not a matter of surprise that the game was generally adopted in the Prussian army, and the list of its admirers now includes those officers of high rank in Prussia who have played a conspicuous part in recent campaigns.

The first requisite for playing the game is to have good maps, on a scale of 8 ins. or more, but not less than 6 ins., to the mile, all the natural features of the ground, the hills and the valleys, the villages and roads, being shown to scale on the plan. The steepness of a hill, and consequently its practicability for the ascent of the different arms, can be judged of from a look at the map, by those acquainted with the system of *contours*, or the lines where horizontal planes at fixed vertical intervals apart cut the surface of the ground. The hills are shown to "scale of shade" on Müffling's principle.

These maps are cut in squares of about 18 ins., and are mounted for convenience on cardboard, so that as many as are required to take in the ground which is to be the scene of the operation, can be placed on the table.

The troops are represented by oblong blocks of lead of different dimensions, which are painted on the upper surface according to the conventional signs for representing troops. They are constructed to the same scale as the map, so that a battalion in line represented by a block of lead occupies the same extent of front on the map as the real battalion would on actual ground. So with smaller bodies, such as companies, squadrons, down to single outposts and videttes, each has a special block of lead to distinguish it. To distinguish the opposed forces, one set of blocks is painted red, the other blue. The front or rear, as the case may be, is also shown.

A scale corresponding to the map, a pair of compasses, and a die comprise all the apparatus necessary.

For the carrying out of a small game—that is to say, of a minor operation of war, as the reconnaissance of an enemy's position, for instance—three players are necessary: one to conduct the game, occupying the position of umpire or referee, the other two to command the contending forces. In a larger game, the chief umpire would be assisted by sub-umpires, and the commanders of forces by troop leaders, &c.

The players being assembled, the chief umpire or instructor gives out the "general idea" (of a similar nature to that given at the autumn manœuvres), fixing definitely the position of the troops in the theatre of war with reference to each other, their bases, lines of communication, &c.—such information, in fact, as would be known to the troops in real war.

Each commander then retires to his own room to consult his map, and to receive from the umpire the "special idea" (the subject of which is of course unknown to the opposed commander), defining the *object* he has to effect, the force at his disposal, &c., &c. The umpire receives from each in writing the disposition of their forces to effect the *object*, which enables him to calculate where and when, by the ordinary rate of march, the two forces would sight each other. To avoid long operations out of range of one another, he fixes this time for the commencement of the game.

The following are copies of the "general" and "special ideas" of a game which the writer recently witnessed at one of the upper military schools in Berlin. The officers conducting the operation had served about four years in the army, during which they had taken part in the campaign of 1870–71. It will serve to show the mode of procedure in conducting a game.

General Idea.

"Situation of affairs as on the day before the battle of Prague, 6th May, 1757. The Austrians in position on the right bank of the Moldau. The King of Prussia had crossed the Moldau and was at Dablitz on the evening of the 5th May; Field-Marshal Count Schwerin at Brandeis.

SPECIAL IDEA.

For Blue (Prussian).

"At 6.30 a.m. on 6th May, the King had joined Schwerin at Gbell. The troops are ready to move forward in the direction of Wissoczan, Hloupetin and Keyge.

"A detachment on the left flank (Northern detachment), under Major A., consisting of

1 Battalion Infantry,
1 Company Rifles,
1½ Squadrons,
1 Battery,

receives orders at Sattalitz at 6.45 a.m. on 6th May, to move off and reconnoitre beyond Hostawitz, the enemy's position, which was supposed to be between Keyge and the Ziskaberg."

Problem.—Orders for the march of the detachment-commander.

SPECIAL IDEA.

For Red (Austrian).

"The Austrian Army will oppose the enemy's attack, holding the position between Keyge and the Ziskaberg.

"A detachment on right flank (Southern detachment), under Major B., consisting of

2 Companies Infantry,
1 Company Rifles,
1 Squadron,
4 Guns,

arrives at Hostawitz at 8 p.m. on 5th, with the object of defending the defiles there against any enterprises on the part of the enemy, and of furnishing intelligence about the enemy early on the following morning."

Problem.—(1) Written orders for the evening of the 5th. (2) Verbal orders for the next morning.

In compliance with the "special ideas," each commander gave in his written orders. The Austrian commander placed his outposts on the evening of the 5th, as he would have done in real war, and these retained the same positions on the morning of the 6th. The Prussian commander moved from Sattalitz as ordered. His dispositions for the march and the position of the Austrian outposts were scrutinised by the umpire with reference to the *object* each commander had in view.

The umpire then decided when the troops were in sight of each other, and therefore what men should be uncovered and placed on the map. The game then commenced. Each commander in turn stated his next move; if he said, "I advance towards the enemy," his troops which were decided to be in sight of the adversary were moved on the map

over a space equal to that which they would pass over *in two minutes* on actual ground. The *pace* at which they are to move is also stated, and provided it agrees with certain rules laid down on this head, is not interfered with by the umpire; of course, for instance, a commander would not be allowed to *double* his troops for several consecutive moves, without moving them at a walk occasionally. Troops out of sight are likewise advanced, but they may be covered by the hand to conceal the design. The game went on by moves until the outposts met, then the advanced guard supported by the battery became engaged, and ultimately the weaker detachment retired.

The reconnaissance involved the passage of a defile in presence of the enemy; the attack and defence of a village and the use of a wood in protecting the retreat, were exemplified and carried out by the players with great intelligence and knowledge of the employment of the three arms.

The umpire then called for opinions from the bystanders, and afterwards criticised the operations himself.

The "moves" are based upon the distance over which troops march in two minutes, which are laid down in the Instructions for the Game as follows:—

"*Infantry*.—March along a road 175 yds. in two minutes; in engagement, 200 yds.; at double, 300 yds. (this can only be done for three out of eight moves, and after each move at double there must follow at least two moves at the ordinary pace); in thick wood, 80 yds.

"*Artillery*.—15-pr. field battery marches 175 yds.; in engagement, 200 yds.; in urgent cases, 500 yds. (two moves out of ten); gallop, 700 yds. (one out of ten) in two minutes.

"*Cavalry, Horse Artillery*.—March 175 yds.; in engagement, 200 yds.; trot and walk, 350 yds.; trot, 500 yds. (for ten moves, then five moves at engagement pace); gallop, 700 yds. (two out of ten); charge, 750 yds. in two minutes."

These rates are modified in certain cases, and must be determined by the umpire—as for instance in the case of bad roads, marching by night, or over steep ground. "In tolerably open woods, cavalry and infantry can move over 175 yds. in two minutes. In thick woods they cannot move at all.

"The establishment of a bridge over a ditch up to 12 ft. in breadth occupies four moves; the throwing of a raft or trestle bridge, material being ready, requires fifteen moves for each 45 yds. of bridge—if not ready, five to ten moves more; and for a pontoon bridge, ten to fifteen moves for each 45 yds. of length. If the work is done under fire, four to six moves more must be added; and if the fire is heavy and cannot be silenced, it is for the umpire to decide if the bridge can be thrown at all.

"The time for conveying an order or for fetching up a commander is two minutes or a 'move' for each 750 yds.

"To send a short order and get an answer by field telegraph also occupies a 'move.'"

By an intelligent use of the above instructions controlled by a good umpire, an operation can be made to approximate to what would actually occur in war. We have not as yet made any mention of how the element of *chance*, which after all affects every operation in the field more or less, is brought to bear in the "Kriegs Spiel."

To take an example, we may wish to attack, and we may have to debouch under an enemy's fire to do so. Well, the probable success of such an operation will depend on many contingencies—the ground may be favourable or the reverse, we may be superior in numbers,* the attack may have been prepared by a powerful artillery fire, or it may be accompanied by a flank attack unseen by the enemy. In the game, the umpire takes all the different points for and against into consideration—the ground, the numbers, the condition of the troops attempting it, &c., &c., and with the assistance of prepared tables, which accompany the Instructions, he decides what faces of the die if turned up in throwing are to indicate success in the operation, and on the other hand what faces are to indicate failure. There are also tables for calculating the losses of troops under fire. All losses of course have to be removed from the board, and must not be employed again.

Everything depends upon having a good umpire, who understands not only the leading of troops, but who can also appreciate all the little contingencies which tend to render the operation possible or the reverse. He has also to decide if a body of troops is beaten, or capable of resistance or of attack, and if not at present able, after the lapse of what time they can again be employed.

A good umpire will select ground which may be expected to give instructive situations, and he must be always ready to criticise the position of the engagement. His decision, it is needless to add, must be final.

The advantages of the "Kriegs Spiel" are, (1) that it teaches the habit of reading a map quickly and correctly. It helps to educate the "eye for ground"—that most necessary gift for all leaders of troops; (2) it compels the players to be quick in deciding the movements of the troops, and to be exact and precise in giving the necessary orders; (3) it enables the players to gain an insight into the harmonious working of the three arms. It shows them that there can be only general principles, not rules, laid down for the disposition of troops, and that the disposition for the ever-varying circumstances of each case must be decided on its own merits; (4) it exhibits the relation between time and space better than in any other way, except of course in the field. By showing the exact time it takes to move troops along a road between one point and another, it teaches the player that he must consider how best he can arrange his troops on the march, and also so *time the commencement of the change*, that they may develop into a body fit for attack in any direction at the shortest notice. It demonstrates how a defile, such as a single bridge over a river, delays the march of troops, which

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* In reckoning numerical circumstances, one battalion is reckoned equal to four squadrons, or to half a battery, or to four skirmisher sections.

otherwise might not be appreciated in timing their arrival on the scene of action.

The two points in which the "Kriegs Spiel" is at a disadvantage are, (1) that the players see more of the ground than they would in reality—for instance, they can see what is going on on the other side of a wood; and (2) the moral condition of the troops is not taken into account—and on this, as we know, the fate of battles mainly depends.

The latter disadvantage—the more important one—applies to field manœuvres also. Notwithstanding these disadvantages, the "Kriegs Spiel" is undoubtedly a very useful means for illustrating minor operations of war, marches, and preliminary movements before battles, and is therefore well adapted for instructing younger officers; but long and desultory operations in a battle should be avoided, as they tend to weary the interest of the players.

Much depends on the umpire, and the value of his opinions after the game is finished.

There remains to be alluded to, a form of "Kriegs Spiel" recently introduced, and one which has found great favour, especially among the artillery and engineers at Berlin, called the "Festungs Kriegs Spiel" in contradistinction to the other form we have been describing, which is called the "Feld," (Field) or "Taktik" (Tactics) "Kriegs Spiel."

The "Festungs" (fortress) or "Belagerungs" (siege) Game has for its object the illustration of the defence and attack of a fortress.

Similar maps are used as for the other game; but in addition to the blocks representing troops, there are blocks to represent earthen batteries, obstacles, and all the other paraphernalia of sieges.

More players are required, and they are divided off to the attack and defence.

In this way the siege of a fortress, from the time the enemy's outposts come in sight of it to the time of breaking ground, the formation of the parallels, zigzags of approach, and batteries, can be exemplified.

It will be easily seen how practical this game may be made. For instance, at a certain time it becomes necessary for the player charged with part of the attack on a fortress to throw up a battery. He intimates his intention to do so to the umpire, to whom he must give a written description of the work, with dimensions of the parts, &c., its armament, the working party, its reliefs, the tools, and so on. He must consider the means of transport to bring up this material; if by rail, he must specify the tonnage, &c.—in fact, just as he would have to do in a real siege.

The following significant fact speaks for itself as to the value of this game. A little more than two years ago, the officers at one of the military schools at Berlin studied the attack and defence of the fortress of Metz, of which fortress and its environs they possessed very excellent and detailed maps on a large scale. Within a year, many of those officers formed part of the force which actually invested that fortress, and from their previous study of the ground, they found themselves well acquainted with every hill and road in its vicinity. No better illustration can be given than this of *their practising in peace what they may have to do in war*, and its manifest advantages.

Some enthusiasts in the "Kriegs Spiel" in Prussia, have gone so far as to say that it may take the place of the autumn manœuvres—that both are not necessary. A little reflection, however, will show that this cannot be so. The autumn manœuvres give practice to officers and men in the appropriation and utilisation of ground, and in accustoming the eye to measurements; they also give practice to general officers and their staff in the giving and execution of orders; and again to all ranks in the carrying out of evolutions, in rapidly changing from the order of march to the order of battle, and the like; and last, not least, they test the supply and transport departments.

In the "Kriegs Spiel" we are not tied down in our operations to the actual troops in garrison, nor have we to adopt false movements from consideration for the crops; and again, we can represent many varying circumstances of the fight on the same ground.

Each is an useful complement of, but can never be a substitute for, the other.

February, 1872.

FLAT TRAJECTORIES: WHAT ARE THEY?

EXEMPLIFIED IN THE CASE OF

SMALL-ARMS AND FIELD ARTILLERY.

A PAPER READ AT THE R.A. INSTITUTION, WOOLWICH, FEBRUARY 29, 1872,

BY

CAPTAIN J. SLADEN, R.A.

MAJOR-GENERAL SIR E. C. WARDE, K.C.B., IN THE CHAIR.

THE subject which I have the honour to bring to your notice to-day has, since the introduction of rifled ordnance, become one of considerable importance. This has been practically recognised in the increased charge of powder used in our latest small-arms and field artillery; the object in view being the projection of the bullet or shell with a high muzzle velocity. For example, the charge of 70 grains of powder for the Snider-Enfield is to be superseded by a charge of 85 grains in the Martini-Henry for the same weight of bullet (480 grains); also, a charge of 1 lb. 2 ozs. in the 9-pr. B.L. has been superseded by a charge of 1 lb. 12 ozs. in the 9-pr. M.L.

What are, then, the advantages of a flat trajectory? They may be summed up chiefly under three heads, viz:—

(1) Greater accuracy.
(2) Harder hitting.
(3) Greater efficiency in covering the ground.

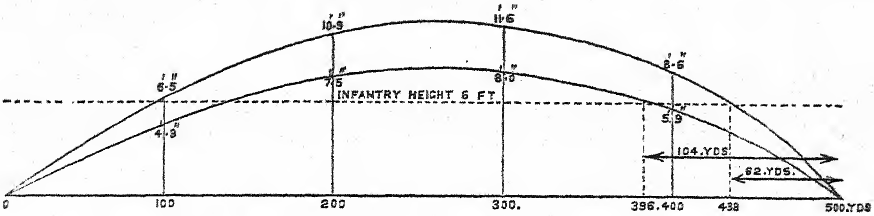
Take the case of small-arms.

(1) Greater accuracy; since the direction of the bullet on striking is less oblique to the target with the flatter trajectory, and consequently small errors in aiming or in judging distance are of lesser importance.

(2) Harder hitting; because, the velocity being higher, if the bullets are the same weight and fired out of similar rifles, the blow must be harder and the penetration greater.

(3) Greater efficiency in covering the ground—called by the French "longueur battue;" because, for the same range, the bullet does not rise so high in the air.

Fig. 1.



Snider.—Highest point of trajectory, 11′ 10¾″. Muzzle velocity, 1252·8 f.s.
Martini-Henry. " " 8′ 1¾″. " " 1362·7 f.s.

Fig. 1 represents approximately the relative trajectories, at 500 yds. range, of the Martini-Henry rifle (·45-in. bore) and the Snider-Enfield (·577-in.), which were taken experimentally by the "Committee on Small-Arms" during their lengthened investigations into the merits of the different rifles proposed to them for adoption into the service in lieu of the Snider-Enfield. Taking 6 ft. as the height of an infantry soldier, the distance covered by the Martini-Henry at 500 yds. range is 104 yds., while the distance covered by the Snider-Enfield is only 62 yds.; or, in other words, the margin allowed for error in judging distance is in the former case 104 yds., in the latter 62 yds. The practical method of determining the trajectory of any rifle is a very simple one; and, care being taken in the selection of a good marksman, it may be determined with considerable accuracy. The rifle is carefully sighted for whatever range the trajectory is to be determined. Suppose 500 yds. The marksman adjusts the sight of the rifle for 500 yds., and, at a distance of 100 yds. from the target, aims at a point on a level with his eye; the bullet hits the target higher than the point aimed at. A group of shots are thus made, and the point of mean impact of the group worked out; the vertical distance of the point of mean impact from the point aimed at is the height of the trajectory at 100 yds. The same process is repeated at 200, 300, and 400 yds. respectively, whence the actual height of the trajectory at these distances is measured on the target. The trajectory may also be calculated when the muzzle velocity of the bullet and the resistance of the air to its motion are known. Trajectories calculated on known dynamical principles, agree very closely with those obtained by actual experiment.

Flatness of trajectory depends principally on three conditions:—

(1) The muzzle velocity of the projectile.
(2) On the rate of diminution of that velocity caused by the resistance of the air.
(3) On the velocity acquired by a body falling freely in the air.

This last is the only one of the three conditions which is the same for every description of shell or bullet. For instance, a bullet of 480 grs. in weight, or a shell of 400 lbs. in weight, if allowed to fall freely in the air, will each acquire the same velocity—viz., 32·2 f.s. in 1 second.

The first condition—*i.e.*, the muzzle velocity—depends mainly on the relative charge of powder to the weight of the projectile—*i.e.*, the greater the charge, the higher the muzzle velocity.

The second—*i.e.*, the rate of diminution of the velocity of the projectile caused by the resistance of the air—is proportional to the square of the diameter of the projectile divided by its weight; thus depending mainly on the relative size of the bore to the weight of the projectile.

Let us now consider the case of a shell projected vertically upwards at a low velocity. For all practical purposes it may be treated as under the influence of gravity alone, where the force of gravity is equal to 32·2 lbs. acting vertically downwards. The tendency of this force is continually to diminish the upward velocity of the shell, till at the end of a certain time it reaches its highest point, remains motionless, and then commences to descend. The force of gravity now increases the velocity of the shell, so that it reaches the ground again with exactly the same velocity with which it was projected. The times of ascent and descent are also equal. For instance, suppose a shell projected vertically upwards with a velocity of 32·2 f.s.; it would ascend for 1 second to a height of 16·1 ft., then it would commence falling, and ultimately arrive at the point of projection with the same velocity it started with, in another interval of 1 second—the total time of ascent and descent being 2 seconds.

This, in other words, is called the "time of flight," and is directly proportional to the upward velocity of projection—*i.e.*, the time of flight is longer, the greater the upward velocity of projection.

When a shell is projected out of a gun at an angle of elevation, its motion may be considered as compounded of two motions—one in a vertical direction, the other in a horizontal direction. The motion in a vertical direction determines the time of flight; the motion in a horizontal direction, the range or distance travelled over during that time.

Now, suppose a shell is fired out of a gun at a low elevation, so as to have a velocity of 32·2 f.s. in a vertical direction, and a velocity of 1300 f.s. in a horizontal direction; it will have a time of flight of 2 seconds, exactly as in the former case, and it will arrive at the highest point of the trajectory (viz., 16·1 ft.) in 1 second. Now, this "time of flight" is the time the projectile has to get over the ground, and since it is travelling at the rate of 1300 ft. per second, it would range, if there were no resistance from the air, $2 \times 1300 = 2600$ ft., or 866 yds. But practically every projectile experiences more or less the resistance of the air, which tends continually to reduce its velocity; and it is just the question of the amount of this resistance which affects the "flatness of trajectory."

Suppose now that, owing to the resistance of the air, the muzzle velocity of 1300 f.s. were reduced to 1100 f.s. at the end of 2 seconds; then the range would be only 791 yds., and the highest point of the trajectory would be, as in the former instance, 16·1 ft. Again, suppose the muzzle velocity of 1300 f.s. were reduced to 1000 f.s. at the end of 2 seconds; the range would be still less—viz., 745 yds.—and the highest point of the trajectory would be, as in the previous cases, 16·1 ft.

Now, what I want to show is this—viz., that for a given time of flight,

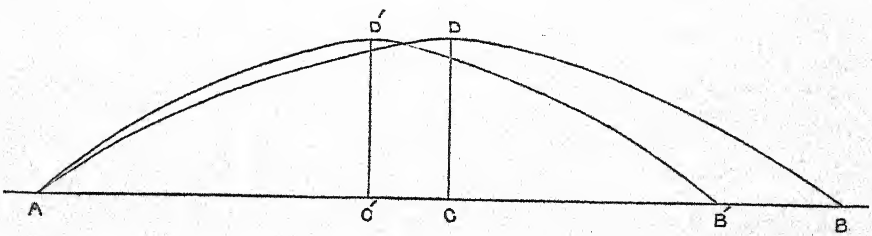
the greatest absolute height of trajectory is the same, whatever the range may be; so that if the time of flight is correctly observed, the absolute height of trajectory is also known, whatever the range may be. Thus, multiply the square of the time of flight in seconds by 4; it will give the greatest height of trajectory. For example, suppose the times of flight of shells fired out of different guns were observed to be 3·0 seconds and 3·3 seconds respectively—

$4 \times (3{\cdot}0)^2 = 4 \times 9 = 36$ ft. would be height of the one trajectory,
$4 \times (3{\cdot}3)^2 = 4 \times 10{\cdot}9 = 43{\cdot}6$ ft. " " the other.

Elevating a gun means giving the shell time to range in. By increasing the elevation of a gun, the time of flight—or the time for the shell to range in—is increased.

From what has been advanced, it will be seen that if two guns are fired at the same elevation (say 2°), and have the *same muzzle velocity*, the time of flight of their shells will be the same, and the greatest absolute height of their respective trajectories will be the same. Also, if the shells have the same weight, and the same form and sectional area, their *trajectories themselves* will be the same, because they will each lose velocity at the same rate; but if one of the shells differ, either in weight, or form, or sectional area, the height of the trajectory will still be the same, yet the *trajectories themselves* will not be the same, because one shell will lose velocity faster than the other, and will consequently range shorter. And here I must give a technical definition of "flatness of trajectory."

Fig. 2.



Let us consider the trajectories ADB and $AD'B'$ representing the case of two shells fired out of different guns with the same elevation and the same muzzle velocity, but subject to a different retardation from the resistance of the air—so that, having the same time to travel in, one arrives at B, and the other at B'. Now, suppose that each of the shells has an upward vertical velocity of 32·2 f.s.; then $CD = C'D' = 16{\cdot}1$ ft. —*i.e.*, the height of the two trajectories ADB, $AD'B'$ is the same. The relative flatness of the trajectory ADB is estimated by the ratio of the greatest height of the trajectory (CD) to the range AB, which varies as

$\frac{CD}{AB}$; the relative flatness of trajectory $AD'B'$ varies as $\frac{C'D'}{AB'}$. Thus the trajectory ADB is the flatter of the two, although having the same absolute height.

The relative shooting powers of different guns have been compared at Shoeburyness on this principle—*i.e.*, firing them at equal elevations; and so long as the muzzle velocities of both the guns are the same, and *the times of flight observed are approximately the same,* the difference in range affords a fair criterion of their respective shooting powers. But there is another point which should not be forgotten, which, if lost sight of, may give rise to an error in judgment. If the muzzle velocities of the guns are *not* the same for equal elevations, the upward velocities of the shells are *not* the same; they are proportional to the muzzle velocities. For instance, suppose two guns laid at 2° of elevation, their muzzle velocities being respectively 1100 and 1200 f.s.; the upward velocities of their shells will be in the same proportion—viz., as 11 to 12; and since this upward velocity really forms the time allowance for the shell to travel in, one has *less time* to travel in than the other, in about the same proportion, and consequently does not range so far as it otherwise would. It would not be supposed that one train travelled faster than another if one went 12 miles in 12 minutes and the other 11 miles in 11 minutes. The question of time comes in; and it is to this point that attention should be especially drawn, as it is so easily overlooked. For this reason it is not correct, in the comparison of two different guns, when the muzzle velocities also differ, to judge exclusively by their respective ranges at the same elevation. The shell with the lower muzzle velocity is unfairly handicapped in point of time, and if its velocity is diminished less rapidly than that of the shell starting with the higher muzzle velocity, the gun which may be the hardest hitter at ordinary artillery ranges appears to be inferior to the other, because, at low angles of elevation, it does not range so far. This seems to have been the case at the comparative trial of two 16-pr. guns at Shoeburyness last year, one having a calibre of 3·3 ins., the other a calibre of 3·6 ins. The Committee recommended the trial of the 3·3-in. gun for the following reasons:—

(1) They believe that a 3·3-in. calibre is theoretically the best for a 16-pr. gun, as giving a greater velocity at 1000 yds., and at all following ranges, over a gun of 3·6-in. calibre.

(2) A shrapnel shell adapted to a 3·3-in. calibre takes an equal number of bullets, and is lighter than that for 3·6-in. calibre.

(3) A common shell for the 3·3-in. calibre, and of the same weight as that for a 3·6-in. calibre, holds ¾ oz. more bursting charge.*

The experiment was conducted in this way:—Each gun was fired at 2°, 5°, and 10° elevation respectively, and the range and deflection observed. Table I. gives an abstract of the practice.

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* "Proceedings of Department of Director of Artillery," Vol. IX. Part 2, p. 116.

TABLE I.

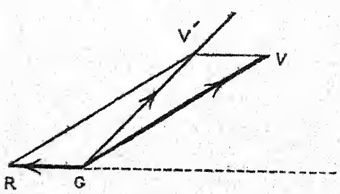
From practice at Shoeburyness, June 8–9, 1871, with the 16-pr. M.L.R. guns of 3·3-in. and 3·6-in. calibre respectively.

Gun.	Number of rounds fired.	Corrected elevation.	Mean time of flight.	Mean range.	Mean difference of range.	Mean reduced deflection.
		° ′	secs.	yds.	yds.	yds.
3·3-inch*	20	2 5	3·0	1057	21·9	0·5
3·6-inch†	20	2 5	3·3	1187	13·2	0·8
3·3-inch†	20	5 3	6·6	2172	20·2	1·7
3 6-inch†	20	5 3	6·7	2228	21·0	1·2
3·3-inch†	20	10 2	12·0	3619	30·3	2·4
3·6-inch†	20	10 2	12·1	3596	27·3	3·0

The muzzle velocity of the 3·6-in. gun was found to be 1358 f.s., that of the 3·3-in. gun 1307 f.s. On reference to the table, it will be seen that at 2° 5′ the 3·6-in. gun ranged 130 yds. farther than the 3·3-in. gun, but it had $\frac{3}{10}$ths of a second longer time to travel in. It is of special importance to notice the time of flight, as it has been already explained that the absolute height of the trajectory for any shell depends on its time of flight; so that if the time of flight is shorter, the height of that trajectory is less. The height of the trajectory for the 3·3-in. gun would be 36 ft., that of the 3·6-in. gun 43·6 ft., assuming the time of flight correctly taken as 3·0 and 3·3 seconds respectively. Again, $\frac{3}{10}$ths of a second more time, when a shell is travelling at the rate of 1000 ft. per second, means 300 ft., or 100 yds., in range; thus accounting for the great difference in range of the two guns when fired at 2° of elevation. The difference in range at 5° shows a considerable falling off from what it was at 2°, while at 10° the 3·3-in. gun has the advantage, although still under the handicap of having less time to travel in.

Another point should be considered in firing guns with equal elevations: the gun which has the quickest recoil *in reality* throws higher than the other. This may be explained by a well-known mechanical

Fig. 3.



principle. Suppose *GV* to represent the rate and direction of the

* Recoil not checked. † Recoil checked.

muzzle velocity of a shell, GR that of the velocity of recoil; completing the parallelogram $GRV'V$, and drawing the diagonal GV', then GV' represents the actual rate and direction of the muzzle velocity, tending to throw the shell higher than the gun is laid. This is on the supposition that the recoil commences before the shell is clear of the muzzle. Again, if the recoil is checked, the gun and carriage have a tendency to rotate on the trail, tending also to increase the elevation. In both these cases the gun which had the liveliest recoil would actually throw the highest. A difference in the preponderance of guns, the carriages on which they are mounted, as well as the nature of the ground on which they are fired, would probably exert some influence on the actual line of fire.

It is probably owing to some of the above reasons that the 3·6-in. gun, when laid at 5° and 10° respectively (the same as the 3·3-in. gun), threw higher than the latter, as the respective times of flight for that elevation clearly indicate (see Table I.) The recoil of the 3·3-in. gun was sensibly less than that of the 3·6-in.; and since the recoil was checked in both cases at 5° and 10° elevation, the 3·6-in. gun had a greater tendency to rotate round the trail than the 3·3-in., and consequently threw higher and ranged farther. If it had been possible to ensure both guns being fired at 5°, the 3·3-in. gun would have ranged the farthest.

I have drawn up a Table of Remaining Velocities, calculated by the law of the resistance of the air approved by the late Ordnance Select Committee—starting with the actual muzzle velocities taken during the experimental trials—by which it appears that, in spite of the 3·3-in. shell starting with 51 f.s. less velocity than that of the 3·6-in., yet at 724 yds. it has actually caught up its rival in velocity, and at 1000 yds. it is travelling 11 ft. per second faster; at 2000 yds., 25 ft. per second faster; at 3000 yds., 34 ft. per second faster; and so on increasingly as the range increases.

TABLE II.

Remaining Velocities of the 3·6-in. and 3·3-in. 16-pr. Guns.

Range.	3·6-in. velocity.	3·3-in. velocity.	Difference in velocity.	3·6-in. energy.	3·3-in. energy.	Comparative per-centage of energy.
yds.	ft. secs.	ft. secs.	ft. secs.	ft. tons.	ft. tons.	per cent.
0	1358	1307	− 51	205	190	− 7·3
724	1087	1088	+ 1	132	132	0
1000	1020	1031	+ 11	115	118	+ 2·6
1500	939	958	+ 19	98	102	+ 4·1
2000	877	902	+ 25	86	91	+ 5·8
3000	779	813	+ 34	67	73	+ 9·0
4000	701	741	+ 40	54	60	+ 11·1
5000	638	682	+ 44	45	51	+ 13·3

Since the efficiency of shrapnel shell (other things being equal) depends on its velocity at the instant of bursting, the higher velocity is of considerable importance. The efficiency of common shell for penetration and destruction of *matériel* (provided the bursting charge is the same) depends on the "energy," or work stored up at the moment of impact. The column in Table II. headed "Comparative Per-centage of Energy," gives the per-centage of energy at different ranges. At 1000 yds., the 3·3-in. shell has 2·6 per cent. greater energy; at 2000 yds., 5·8 per cent.; and at 3000 yds., 9 per cent.; and so on increasingly as the range increases. Yet, owing to the method of experimenting, and judging exclusively from the ranges obtained at equal angles of elevation, the harder hitting of the 3·3-in. gun at ordinary artillery ranges has been practically overlooked. Had the guns been tried, as they would be in actual service, at certain definite ranges—viz., 1000, 2000, and 3000 yds.—giving each gun its proper elevation to strike a target at these ranges, and estimating by the effects produced, the opinion of the Committee might have been greatly modified.

If a 3·3-in. gun, built on the lines of a 3·6-in. gun, proves itself a hard hitting gun, it may reasonably be expected that a 3·3-in. gun constructed on its own lines will be still better.

The practical way to compare the "flatness of trajectory" of any two guns, would be to give each of them such an elevation that their respective times of flight may be *equal;* then the gun which ranges the farthest has the flatter trajectory for that range. Also, the practical way of comparing the relative power of any two guns, would be to fire them at such an elevation that they should both strike an object at a fixed range; the gun which hits the hardest (*cæteris paribus*) is the most powerful gun at that range.

The method of judging by range irrespective of time is most fallacious, as it leads to an unfair conclusion; for, in the first place, the trajectory itself may not be so high, and the time for travelling may be less. By giving a little more elevation to the gun with a lower muzzle velocity, the time of flight may be equalised; then they would both have the same height of trajectory, and the same time to travel in.

There is a manifest discrepancy in the ranges of the 3·3-in. and 3·6-in. guns for 2° 5′ elevation (see Table I.) By calculation it may be shown that the correct range for the 3·3-in. gun at 2° 5′ elevation would be about 1057 yds.—the same as that determined by experiment; also, the correct range for the 3·6-in. gun at the same elevation would be about 1087 yds.—*i.e.*, 100 yds. less than that determined by experiment. It can only be accounted for from the fact of the 3·3-in. gun being allowed to recoil, while the recoil of the 3·6-in. gun at the same elevation was checked.*

Again, the fact of taking only muzzle velocity into consideration has led to a misapprehension. The higher muzzle velocity of the 3·6-in. gun, instead of proving the inferiority of the 3·3-in. gun, proves

* "Proceedings of Department of Director of Artillery," Vol. IX., p. 118.

its superiority in this respect—that with less strain on carriage and less recoil, it actually throws a shell with greater velocity from about 724 yds. and upwards, and has a flatter trajectory beyond 1600 yds. range. The truth of this is manifest from the actual experiment; for at about 3000 yds. the 3·3-in. shell caught up the 3·6-in. in actual range, with $\frac{1}{10}$th of a second less time of flight; and since it started with a lower velocity, it is evident that it must have been travelling faster, at least for the last $\frac{2}{3}$rds of the range—*i.e.*, the last 2000 yds.—or it would never have caught it up. One thing the experiment does show—that 3 lbs. of R.L.G. powder are not so effectively consumed in a 3·3-in. as in a 3·6-in. bore of the *same length;* but which is of the most importance—burning the powder, or destroying the enemy? Besides, it has not been shown that L.G. powder, of which we have a large store, would not have given a better result as regards muzzle velocity in comparison with the 3·6-in., than the R.L.G. has done. A charge of 3 lbs. of L.G. powder has been fired in the 3·6-in. gun, and has given a muzzle velocity of only 1283 f.s. Service L.G. powder has a smaller grain than service R.L.G., and therefore might burn quicker—although it is unsafe to predict, with our present knowledge, what powder will do.

Again, the experiment has shown that a 16-lb. shell, in spite of its increased length, can be fired out of the 3·3-in. gun with as much accuracy as regards range and deflection as from the 3·6-in. gun; and since the "useful capacity of the shrapnel shell is not materially affected by the decrease of diameter,"* there can hardly be any practical objection on that account.

For firing reduced charges, such as are used in high-angle practice, the 3·3-in. gun would have the advantage, as the cartridge would be longer; and it would perhaps permit the vent being placed 3 ins. from the rear end of the bore, and still allow of the residue of the smallest cartridge being completely burnt up. This position of the vent would also help to give a greater muzzle velocity, as in all probability more of the powder would be burnt up.

Indeed, all the so-called theoretical hypotheses have been completely established by the experiment, and a way has been indicated of obtaining the greatest mechanical effect from a given weight of gun. The great test of a gun is hard hitting at ranges varying from 1000 to 3000 yds.; not the actual range for a fixed angle of elevation. What does it matter whether a gun is fired at 2° 5′ or 2° 15′, provided the object is struck? The real questions at issue are:—(1) Which is the longest ranging gun? (2) Which is the hardest hitting gun? The conclusion from the experiment is that the 3·3-in. is the longest ranging gun, and also the hardest hitting at all ranges above 724 yds. The advantage, then, of constructing a gun with 3·3 ins. calibre would be, that with a lighter gun and carriage (the recoil being less violent), a longer ranging and a more powerful gun at all ordinary ranges of artillery fire could be made.

Again, advantage might be taken of the smaller bore to reduce the

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* Report of Committee on High-Angle and Vertical Fire, p. 3.

weight of the 16-pr. gun and carriage. A gun of 3·3-in. calibre might be constructed to throw a 16-lb. shell with a charge of $2\frac{1}{4}$ lbs. of R.L.G. powder, and weighing a little over 10 cwt. instead of 12 cwt.; which, taking into consideration a slight reduction in the weight of the carriage, would give a clear gain of 3 cwt. in mobility. This would reduce the total weight behind team from 41 cwt. to about 38 cwt., allowing the equipment to remain the same as at present. The argument against such a gun would be, "The trajectory will not be so flat." But what is gained by having such a flat trajectory? Nothing, at the ordinary ranges of artillery fire, compared with what is lost in mobility. The charge of $2\frac{1}{4}$ lbs. of powder would give a muzzle velocity of about 1200 f.s., and would strike as hard a blow at 2000 yds. as the present 16-pr. gun with a charge of 3 lbs. of R.L.G. powder, but would have a somewhat higher trajectory. It may be remarked that the term, "a flatter trajectory," has sometimes a misleading tendency. It is a fact which may be easily remembered, that the difference in the flatness of trajectory of any field guns is of very little importance, although for small-arms, when the ranges are short, it is of great importance. Of course I am not now speaking of the comparison of two particular guns, for then that which has the flatter trajectory is the better of the two (*cæteris paribus*); but I am speaking of efficiency in connection with mobility—taking a more comprehensive view of the question. For instance, at 5° elevation the range of the service 16-pr. is 2228 yds., and time of flight 6·7 seconds, so that the height of the trajectory is $4\,(6{\cdot}7)^2 = 179$ ft. The 12-pr. B.L. Armstrong gun would range about the same distance at 6° of elevation, with a time of flight of 7·4 seconds. The height of trajectory of the 12-pr. B.L. would then be $4\,(7{\cdot}4)^2 = 219$ ft.; and as we are not likely to encounter men 100 ft. high, the difference in height is of no importance. The only point of importance is the "longueur battue," which may be estimated from the angle of fall. It is a good rule to remember that the angle of fall is about $\frac{1}{3}$rd more than the angle of elevation. This would give 6° 40′ as the angle of fall of the 16-pr. M.L., and 8° for the 12-pr. B.L., at the range of 2228 yds.; and taking the height of a man as 6 ft., the dangerous space or ground covered by the former would be 17 yds., by the latter 14 yds. A 16-lb. shell, fired with a charge of $2\frac{1}{4}$ lbs. of R.L.G. powder from a 3·3-in. bore, would cover more ground than the 12-pr. B.L. at that range; so that the conclusion seems just that at 2000 yds., where it would strike as hard a blow as the service 16-pr. gun, there would be hardly any practical disadvantage in its higher trajectory. Also, the conditions are not the same as in small-arms, where "every bullet has its billet," but we are considering shell, the explosion of which would be felt over a larger area. A muzzle velocity of about 1200 f.s. is quite enough for any field gun of ordinary construction, and indeed for any gun where weight is an object. If this muzzle velocity is much exceeded, it is true that some advantage is obtained for very short ranges, but not corresponding to the extra weight entailed. Thus, it is easy to get a muzzle velocity of 1200 f.s. from a 9-pr. of 6 cwt.—*i.e.*, 200 f.s. per cwt. According to this proportion, a muzzle velocity should be obtained from a 9-pr. of 8 cwt. of

$8 \times 200 = 1600$ f.s., whereas the velocity is about 1350 f.s. The extra weight does not give increased muzzle velocity in the same proportion.

Another reason why 1200 f.s. is about the greatest velocity necessary to get the most out of our guns for a given weight of metal, is that below 1200 f.s. the resistance of the air commences to diminish very rapidly, compared to what it is above that velocity; so that less work is taken out of the shell. This principle is well understood in practice, where results are seen. For instance, in an engine, a certain amount of fuel produces a definite pressure of steam in the boiler; by increasing the supply of fuel a greater pressure may be obtained, but perhaps not in proportion to the increased fuel burnt. The question is—Will it pay? The same thing occurs in guns. It is easy to get a higher muzzle velocity in guns, but it must be paid for in weight of metal. Does the extra weight of metal necessary to produce a higher velocity pay? No; not under ordinary circumstances. We should increase the power of our heavy M.L. guns, if with the same charge of pebble powder a heavier shell were used, so as to reduce the muzzle velocity to about 1200 f.s., provided there is sufficient twist in the guns to spin a longer shell. The same principle holds in the 9-pr. M.L. of 8 cwt. If a 12-lb. shell were fired with the same charge of 1 lb. 12 ozs., the muzzle velocity would be about 1200 f.s., and the gun would be more powerful, and greater useful effect would be obtained from the weight of metal in the gun at all ranges.

In conclusion, when it is necessary to make a comparison between two different systems, where either the weight of shell, charge of powder, weight of gun and carriage, diameter of bore, or muzzle velocity may differ, the total weight of gun and carriage in each case should be approximately the same, and their relative power should be ascertained by the effects produced at the ordinary ranges of artillery fire, giving each gun its proper elevation for that range. For example, the weight of gun and carriage of the British 9-pr. M.L. horse artillery gun is about 19·5 cwt., that of the Prussian 15-pr. (heavy field battery) gun and carriage is about the same (19·5 cwt.); a comparison of the effects of these guns at fixed ranges on targets or earthworks would test the merits of either system —*i.e.*, whether it is best to fire a heavy shell with a low velocity, or a light shell with a high velocity, from a gun of the same weight. The weight of gun and carriage of the Prussian 9-pr. horse artillery gun is only 15 cwt., so that no just comparison can be made between it and the British 9-pr. M.L. The argument in favour of the comparison is, that this is the existing state of things; but it by no means follows that it must always be so. If the Prussians, with their recent experience, think it would be advantageous to construct a gun and carriage of greater weight, they can easily produce a more powerful gun. Therefore, if it is wished to give a decisive test to our present system of M.L. field artillery, it would be well to compare them with equal weights of other systems, and not to blind ourselves with the idea that we have more powerful guns than our neighbours because our 9-pr. of 8 cwt. is superior to their 9-pr. of 6 cwt., and because they have not yet attempted to construct so heavy a field gun as our 16-pr. The opinion of the Prussians is well expressed in their "Officers' Handbook:"—

"The 9-pr., as regards practice, is in no way inferior to the 15-pr.; but it is obvious that an individual 15-pr. projectile must do greater damage on any fixed object which it may strike—such as a house, a wall, &c.—than the 9-pr. For this reason, to cannonade such an object the 15-pr. would be preferable; whilst against troops, generally speaking, the one calibre has no advantage over the other. The sole advantage of the 15-pr. is the greater moral effect it has under certain circumstances. The advantages the 9-pr. has over the 15-pr. consist chiefly in the larger supply of ammunition, whereby the former is more independent of its wagons; another advantage lies in the fact that its pace is faster, and can be longer kept up."*

Recent accounts from India seem to indicate the want of mobility of our 9-pr. M.L. for horse artillery—corresponding, so far as weight is concerned, with the Prussian 15-pr. The "Times" military correspondent states, with regard to the manœuvres at Murowlie, that "General Tombs had given his men a very long day's march—near thirteen hours—with disastrous results to Sir William Hamilton's battery of horse artillery, of which four horses died of exhaustion within the next forty-eight hours. This battery had just been equipped with the new 9-pr. muzzle-loading bronze gun; and it is certainly an extremely unsatisfactory commencement to its working in this country, that on the very first occasion of its being subjected to a really hard trial, the horses should suffer so much."

This may or may not be exaggerated, but I think we should all agree with the maxim of Marshal Marmont, mentioned by Lieut. H. W. L. Hime, R.A., in his recent valuable papers on the "Mobility of Field Artillery:"—"Le premier mérite de l'artillerie après la bravourie des canoniers et la justesse du tir, c'est la mobilité."

At the conclusion of the reading—

Major-General Sir E. C. Warde invited the audience generally to discuss the several questions in connection with the subject of flat trajectories which had been dealt with during the lecture.

Captain Maitland, R.A., said the lecturer had spoken of the bursting charge of the 3·3-in. shell as being ¾ oz. more than that of the 3·6-in. It appeared to him that the weight of the bursting charge must depend in a great measure on the thickness of the walls of the shell.

Captain Sladen said he had spoken of the bursting charge of a 3·3-in. shell as it had been measured by the Committee. He had referred to the statement of the Committee when they recommended the trial of the 3·3-in. gun; but an improvement had since been made in the capacity of the 3·6-in. shell, so that it now contained a slightly greater bursting charge than the 3·3-in. shell, both having the same thickness of wall.

Major-General Sir E. C. Warde, having paused to ascertain if there was any

* *Vide* "Field Gun for India," by Colonel Maxwell, R.A., "Proceedings, R.A. Institution," Vol. VI. p. 488.

intention of continuing the discussion, said that from the position he occupied, and the duty he had been requested to undertake, it now became his agreeable task to convey to their friend Captain Sladen their hearty thanks for his interesting discourse; and he thought that he might express on behalf of all present the hearty gratification they had derived from his able treatment of his subject, and the clear manner in which he presented all its details. The facts with which he had dealt were full of information and interest to many of them, and he could only repeat what he said twelve months ago, when attending Captain Sladen's previous lecture, that it gave him great pleasure—having watched him from the day he joined the corps—to see him pursuing a course which must redound to the honour and credit not only of himself, but of that great and distinguished corps to which they all felt a pride to belong. (Applause.)

Lieut. KENSINGTON, R.A., returning to the subject of the lecture, said that although the Committee on the 16-pr. field gun had reported in favour of the 3·6-in. bore, all who had heard the arguments of Captain Sladen were probably convinced that the 3·3-in. would be better. At all events, no one had disputed his conclusions, and therefore he might take them for granted. Therefore, as it was self-evident that the artillery should have the very best tools to work with, he thought it would be a pity to draw into the service a gun which was not the very best, and hoped that they would all devote their energies to securing the gun which they believed to be better.

Major-General Sir E. C. WARDE.—But are we all agreed on the subject?

Lieut. KENSINGTON.—There is no dissenting voice, and I take it for granted that we are.

Major-General Sir E. C. WARDE.—But we are only a small proportion of the whole corps.

Lieut. KENSINGTON.—We may, I think, be fairly regarded as representative of the regiment, and we are certainly a large proportion of those officers who interest themselves in such questions.

Major-General Sir E. C. WARDE.—I hope the time will come when larger numbers will attend and take an interest in these questions. The point occurred to me during the lecture, that the 16-pr. gun, being a gun for special purposes, a shell of 3·6 ins. would probably be, from its larger capacity, more effectual than that of 3·3 ins.

Captain SLADEN.—The two shells are on the table; there is practically no difference in their efficiency.

Major-General Sir E. C. WARDE.—If that is so, and we can get a suitable gun of the same power as the larger one, there is no doubt that we shall obtain thereby a practical advantage; for we shall have a lighter weight to carry, and therefore greater mobility—which is one of the main points. But supposing we all concur in the belief that the smaller bore would be preferable, I should think it would be better that any suggestion to that effect should come, not from this meeting, but from the Committee of the Institution.

Colonel MILWARD, C.B., R.A., Superintendent Royal Laboratories, said it was a dangerous thing in these times, when there were so many committees of investigation, to express any opinion as to the merits of rival schemes, and he should abstain from advancing any views of his own upon the subject under discussion. But he wished to say simply that the two guns—the 3·6-in. and 3·3-in. guns—were handed over to a committee of which the President was Major-General Eardley-Wilmot—an officer concerning whose judgment and integrity they all held a very high opinion—and that committee reported that the advantage was in favour of the 3·6-in. gun. Now Captain Sladen had made it appear that the advantage was in favour of the 3·3-in., and what they wanted was some one on the other side to take up the cause of the larger bore.

Major-General Sir E. C. WARDE.—*Audi alteram partem,* you mean.

Colonel MILWARD.—Yes; it appears clear to us at present that the 3·3-in. has certain important advantages, but I am sure that an officer like Major-General Eardley-Wilmot and his Committee would not form a deliberate opinion without some grounds for doing so.

Colonel YOUNG, R.A., said they must all agree that Captain Sladen had treated his subject very ably—(applause)—and he did not rise for the purpose of disputing any of the facts advanced in his lecture. But Captain Sladen had said, in reply to a question, that there was no practical difference in point of efficiency between the two projectiles; and that remark was open to objection. Now, he thought it might be taken for granted, as beyond a doubt, that the nearer they got to a sphere in the shape of the projectile the better, and that if they unduly elongated the shell they not only weakened its efficiency in striking, but were bound to have a sharper twist in the rifling, which would make the strain on the gun more severe; or they must make the gun longer, and that would make it more unmanageable. Again, with the shrapnel shell, the bullets would scatter more on bursting from a long shell than a small one; so that there really were some advantages in the 3·6-in. gun. However, he himself thought at the time the bore was decided upon that it was rather large, because he had been thinking to establish a law upon the subject, and his idea was that the bore should have been something between the two calibres. It was only, however, on the subject of the projectile that he differed from the lecturer.

Major-General Sir E. C. WARDE said Captain Sladen had better issue a challenge to the advocates of the 3·6-in. gun to meet him and discuss the subject out.

Lieut. C. JONES, R.A., said there was not the slightest doubt that the 3·3-in. gun would strike a harder blow at any range above 724 yds.; but as these guns were only to be introduced for a special purpose, it might be worth while considering if they could not practically reduce the 3·6-in. bore by increasing the weight of its projectile, making it an 18 or 20-pr. instead of a 16-pr.

Major-General Sir E. C. WARDE said he understood that the gun was not intended merely as a reserve for special purposes, but that it was to form a considerable part of the batteries.

Colonel MILWARD said he believed the gun was to be largely introduced into the service.

Lieut. JONES said, if that were the case, there would be no advantage in carrying out his suggestion.

Captain SLADEN, replying to the objections raised with regard to the length of the 3·3-in. shell, contended that for the demolition of earthworks the 3·3-in. shell would hit harder and penetrate deeper than the 3·6-in. shell, and from the greater distribution of the bursting charge, the damage inflicted by the longer shell would be as great or greater than that inflicted by the shorter one; and that for a common shell to act with a percussion fuze, it would break into a greater number of pieces. But all he asked for was that the two guns should be tried at fixed ranges instead of fixed elevations. He did not say that the 3·6-in. gun was not a powerful gun, but that it is not the most powerful 16-pr. gun which could be made with the weight allowed. He thought he had a right to defend himself from certain attacks, one of which they might have seen in the "Times" of the 24th January, 1872, speaking of the "evil moment when the Committee were induced to listen to some purely speculative and theoretical arguments," and insinuating that they were the ideas of a "theorist and schoolman." (Applause.)

Major-General Sir E. C. WARDE.—On one point we are all agreed, and that is that Captain Sladen has proved himself to be neither a theorist nor a schoolman. (Applause.)

[At this point in the proceedings Sir Edward Warde took his leave, with an apology, having to travel by rail, and the chair was taken by Colonel Domville, R.A.]

Captain C. ORDE BROWNE, said he fancied that the 16-pr. was really intended

in some measure for a gun of reserve, and if so, long range became of the utmost importance; for when it became necessary to bring the gun into action, every hundred yards it had to advance brought it a hundred yards further into the zone of the enemy's fire. (Hear, hear.) If, therefore, it was important or desirable that any gun should have long range, it should certainly be a gun of reserve. Most writers on artillery stated that it was next to impossible for anything like an equal number of guns to be brought into action on both sides in the same time, and that those first in action had an advantage of two to one; therefore, in order that this might be speedily accomplished, long range was most desirable. (Applause.) The flat trajectory was, he contended, of great advantage to the efficiency of the shrapnel shell on striking; and he added that all these points ought to be fully and freely discussed, instead of taking it for granted that because a committee had decided there was no ground left for debate. (Applause.)

Captain MORGAN, R.A., said his mind was not yet made up as to which gun should have the preference, but the advantages claimed by Captain Sladen for the smaller bore were beyond dispute. They could get harder hitting and greater velocity over 2000 yds. out of the proposed 3·3-in. gun of 10 cwt. than out of the 3·6-in. of 12 cwt. The gun, too, was lighter, and the mobility greater; all of which were undoubted advantages. But the question at issue went far beyond this—so far that he could not enter into it. Just to show the difficulties involved in the question, they had on the one hand the small-arms, in which the velocity of the Snider rifle was inferior to that of the Martini, with its smaller bore; and on the other hand, when they came to large guns, they found the velocity the greatest in the larger bore; the explanation being that in the one case it was a question of the rifling, and in the other a question of the projectile. They were obliged to limit the velocity of the Snider to 1290 ft. per second, because the substance of the bullet would not resist a greater pressure; but with the Martini-Henry, having a harder bullet, they could get a much higher velocity. In the case of the 16-pr., the only question, he thought, was—which is the best shell? for all the other points were in favour of the smaller bore.

Colonel MILWARD said he might remark that there were reasons why, in the construction of a shrapnel shell, there was a disadvantage in having it longer than at present. Mind, he expressed no opinion in favour either of the 3·6-in. or 3·3-in. gun—(laughter)—all that he said was, that the shorter shell afforded greater advantages in construction. He wished to say also that he feared his friend Captain Browne had mistaken him in supposing that he wished to damp discussion. Nothing was further from his meaning; all he meant being that there might be more reason in favour of the 3·6-in. gun than they were disposed to acknowledge, inasmuch as a committee had already come to a conclusion in its favour. (Hear, hear.)

Colonel DOMVILLE said they were very much indebted to Captain Sladen for his lecture, and, from the discussion which had taken place, there seemed little doubt as to the advantages of the gun he advocated. He hoped that some day Captain Sladen would favour them with more on the same subject—(hear, hear)—especially if there was anything to be said on the other side. He thanked him for his lecture, and also, in the name of the meeting, expressed their thanks to Sir Edward Warde for his kindness in taking the chair. (Applause.)

February 29, 1872.

93. Table giving the calculated remaining velocity and energy, at various distances, of projectiles fired from the service M.L.R. guns with battering charges of P. powder. (*Submitted to Department of Director of Artillery by Captain W. H. Noble, R.A., 1. 4. 71. A table at par.* 82, *page* 135 "*Short Notes,*" *affords corresponding results with R.L.G. powder.*)

Range.	12-inch M.L.R. of 25 tons. charge 85 lbs., pro. 600 lbs.			11-inch M.L.R. of 25 tons. charge 85 lbs., pro. 535 lbs.			10-inch M.L.R. of 18 tons. charge 70 lbs., pro. 400 lbs.			9-inch M.L.R. of 12 tons. charge 50 lbs., pro. 250 lbs.			8-inch M.L.R. of 9 tons. charge 35 lbs., pro. 180 lbs.			7-inch M.L.R. of 6½ tons. charge 30 lbs., pro. 115 lbs.		
	v.	Total energy.	Energy per inch of shot's circumference.	*v.*	Total energy.	Energy per inch of shot's circumference.	*v.*	Total energy.	Energy per inch of shot's circumference.	*v.*	Total energy.	Energy per inch of shot's circumference.	*v.*	Total energy.	Energy per inch of shot's circumference.	*v.*	Total energy.	Energy per inch of shot's circumference.
yds.	ft.	ft.tons	ft.tons	ft.	ft.tons	ft.tons	ft.	ft.tons	ft.tons	ft.	ft.tons	ft.tons	ft.	ft.tons	ft.tons	ft.	ft.tons	ft.tons
0	1300	7030	188	1315	6415	187	1364	5160	165·6	1420	3496	124·7	1413	2492	100·2	1525	1855	85·3
200	1273	6750	181	1289	6165	180	1336	4950	158·9	1379	3297	117·6	1369	2339	94·0	1467	1716	78·9
400	1248	6480	174	1265	5935	173	1308	4745	152·3	1341	3117	111·2	1327	2198	88·3	1409	1583	72·8
600	1224	6230	167	1242	5720	167	1280	4575	146·8	1304	2948	105·2	1286	2064	83·0	1356	1466	67·5
800	1201	6000	161	1220	5520	161	1254	4360	140·0	1270	2796	99·8	1248	1944	78·1	1307	1362	62·7
1000	1179	5780	155	1199	5335	156	1228	4185	134·2	1236	2648	94·5	1213	1837	73·8	1261	1268	58·3
1200	1157	5570	149	1179	5155	150	1204	4020	129·0	1204	2513	89·7	1180	1738	69·9	1217	1181	54·3
1400	1137	5380	144	1159	4985	145	1181	3870	124·1	1174	2389	85·3	1150	1651	66·3	1177	1105	50·8
1600	1118	5200	139	1139	4815	140	1159	3725	120·0	1147	2281	81·4	1122	1571	63·2	1141	1038	47·8
1800	1101	5040	135	1122	4670	136	1138	3590	115·3	1121	2178	77·7	1097	1502	60·4	1108	979	45·0
2000	1085	4890	131	1106	4540	132	1118	3470	111·2	1097	2086	74·4	1074	1440	57·9	1078	927	42·6
2200	1069	4750	127	1090	4410	129	1099	3350	107·5	1075	2003	71·5	1052	1381	55·5	1053	884	40·7
2400	1055	4630	124	1075	4285	125	1082	3245	104·2	1055	1930	68·9	1032	1329	53·4	1030	846	38·9
2600	1041	4510	120	1061	4175	122	1066	3150	101·1	1037	1864	66·5	1014	1283	51·6	1009	812	37·3
2800	1028	4400	117	1048	4075	119	1052	3070	98·5	1020	1804	64·4	996	1238	49·8	990	782	36·0
3000	1016	4300	115	1036	3980	116	1038	2990	95·9	1004	1747	62·4	980	1199	48·2	973	755	34·7
3200	1004	4200	112	1024	3890	113	1025	2915	93·5	990	1699	60·6	965	1162	46·7	958	732	33·7
3400	993	4100	110	1012	3800	111	1013	2845	91·3	978	1658	59·2	952	1131	45·5	945	712	32·8
3600	984	4030	108	1002	3725	109	1002	2785	89·4	966	1618	57·7	940	1103	44·3	934	696	32·0
3800	976	3960	106	994	3665	107	992	2730	87·6	955	1581	56·4	930	1080	43·4	924	681	31·3
4000	968	3900	104	986	3605	105	982	2675	85·8	945	1548	55·2	920	1056	42·5	916	669	30·8

94. Table showing the mean muzzle velocity of projectiles fired from the service rifled guns. (*Submitted to the Department of Director of Artillery by Captain W. H. Noble, R.A.*, 1. 1. 72. *A table at par.* 73, *page* 120 "*Short Notes," gives the velocities obtained with R.L.G. powder only.*)

Nature of Gun.	Calibre.	Length of bore in calibres.	Charge.		Projectile.			Mean muzzle velocity.
			Nature of powder.	Weight.	Nature.	Mean weight.	Mean diameter.	
	ins.			lb. oz.		lbs.	ins.	f.s.
12-inch M.L. of 35 tons	12·0	13·5	P.	110 0	Palliser.	700	11·92	1300
12-inch M.L. of 25 tons	12·0	12·0	P.	85 0	"	600	11·92	1300
			P.	85 0	Com. shell.	495	11·92	1358
			P.	55 0	"	495	11·92	1142
			R.L.G	67 0	Palliser.	600	11·92	1180
			R.L.G	67 0	Com. shell.	495	11·92	1271
			R.L.G	50 0	"	495	11·92	1140
11-inch M.L. of 25 tons	11·0	13·2	P.	85 0	Palliser.	535	10·92	1315
			P.	85 0	Com. shell.	535	10·92	1315
			R.L.G	70 0	Palliser.	535	10·92	1217
			R.L.G	70 0	Com. shell.	535	10·92	1217
10-inch M.L. of 18 tons	10·0	14·5	P.	70 0	Palliser.	400	9·92	1364
			P.	70 0	Com. shell.	400	9·92	1340
			P.	44 0	"	400	9·92	1125
			R.L.G	60 0	Palliser.	400	9·92	1298
			R.L.G	40 0	Com. shell.	400	9·92	1117
9-inch M.L. of 12 tons	9·0	13·9	P.	50 0	Palliser.	250	8·92	1420
			P.	50 0	Com. shell.	250	8·92	1420
			R.L.G	43 0	Palliser.	250	8·92	1336
			R.L.G	43 0	Com. shell.	250	8·92	1336
			R.L.G	30 0	"	250	8·92	1192
8-inch M.L. of 9 tons	8·0	14·8	P.	35 0	Palliser.	180	7·92	1413
			P.	35 0	Com. shell.	180	7·92	1413
			R.L.G	30 0	Palliser.	180	7·92	1330
			R.L.G	30 0	Com. shell.	180	7·92	1330
			R.L.G	20 0	"	180	7·92	1163
7-inch M.L. of 7 tons	7·0	18·0	P.	30 0	Palliser.	115	6·92	1561
			P.	30 0	Com. shell.	115	6·92	1561
			R.L.G	22 0	Palliser.	115	6 92	1458
			R L.G	22 0	Com. shell.	115	6·92	1458
			R.L.G	14 0	"	115	6·92	1258
7-inch M.L. of 6½ tons	7·0	15·9	P.	30 0	Palliser.	115	6·92	1525
			P.	30 0	Com. shell.	115	6·92	1525
			R.L.G	22 0	Palliser.	115	6·92	1430
			R.L.G	22 0	Com. shell.	115	6·92	1430
			R.L.G	14 0	"	115	6·92	1230
80-pr. M.L. of 101 cwt., converted from 68-pr. S.B. of 95 cwt.	6·3	18·0	L.G.	10 0	"	80	6·22	1240

(*Continued.*)

Nature of Gun.	Calibre.	Length of bore in calibres.	Charge.		Projectile.			Mean muzzle velocity.
			Nature of powder.	Weight.	Nature.	Mean weight.	Mean diameter.	
	ins.			lb. oz.		lbs.	ins.	f.s.
64-pr. M.L. wrought-iron of 64 cwt.	6·3	15·5	R.L.G	8 0	Com. shell.	64	6·22	1252
			L.G.	8 0	〃	64	6·22	1229
64-pr. M.L. of 58 cwt., converted from 32-pr. S.B. of 58 cwt.	6·3	17·2	R.L.G	8 0	〃	64	6·22	1245
64-pr. M.L. of 71 cwt., converted from 8-inch S.B. of 65 cwt.	6·3	16·4	R.L.G	8 0	〃	64	6·22	1230
40-pr. M.L. of 35 cwt.*	4·75	18·0	R.L.G	8 0	〃	40	4·69	1357
			R.L.G	7 0	〃	40	4·69	1336
			R.L.G	6 0	〃	40	4·69	1305
25-pr. M.L. of 21 cwt.*	4·0	18·0	R.L.G	5 0	〃	25	3·94	1355
			R.L.G	4 8	〃	25	3·94	1320
			R.L.G	4 0	〃	25	3·94	1278
16-pr. M.L. of 12 cwt.	3·6	19·0	R.L.G	3 0†	〃	16	3·54	1352
			R.L.G	2 8	〃	16	3·54	1273
			R.L.G	2 0	〃	16	3·54	1167
9-pr. M.L. of 8 cwt.	3·0	21·3	R.L.G	1 12†	〃	9	2·94	1381
			R.L.G	1 8	〃	9	2·94	1325
			R.L.G	1 4	〃	9	2·94	1203
9-pr. M.L. of 6 cwt.	3·0	17·5	R.L.G	1 12	〃	9	2·94	1262
			R.L.G	1 8†	〃	9	2·94	1234
7-pr. M.L. of 220 lbs. (bronze)......	3·0	11·3	F.G.	0 12†	〃	7·25	2·94	955
			F.G.	0 10	〃	7·25	2·94	854
7-pr. M.L. of 150 lbs. (steel)	3·0	8·0	F.G.	0 6	〃	7·25	2·94	673
7-inch B.L. of 82 cwt.	7·0	14·2	R.L.G	10 0	〃	110	7·09	1013
			R.L.G	11 0	〃	90	7·09	1165
64-pr. B.L. of 61 cwt..................	6·4	10·9	R.L.G	9 0	〃	64	6·48	1200
40-pr. B.L. of 35 cwt..................	4·75	22·4	R.L.G	5 0	〃	41	4·8	1180
20-pr. B.L. of 16 cwt. (land service).	3·75	22·4	R.L.G	2 8	〃	21	3·8	1130
20-pr. B.L. of 13 cwt. (sea service).	3·75	14·5	R.L.G	2 8	〃	21	3·8	1000
12-pr. B.L. of 8 cwt.	3·0	20·5	R.L.G	1 8	Segt. shell.	11·75	3·07	1150
9-pr. B.L. of 6 cwt......................	3·0	17·7	R.L.G	1 2	〃	9·25	3·07	1057
6-pr. B.L. of 3 cwt......................	2·5	21·2	R.L.G	0 12	〃	6·6	2·57	1046

* These guns are not yet finally approved of. † Service charge.

95. "DIE KARTÄTSCHGESCHÜTZE." By R. Wille, Prem. Lieut. Berlin, Mittler & Son.

(Contributed by Captain F. C. H. Clarke, R.A.)

This pamphlet is the expression of the general feeling now prevalent in Prussia with regard to the mitrailleuse question.

The opinions formed in Prussia on the use of mitrailleuses in the field have been strengthened by the experiences of the war of 1870–71, and the official determination not to employ them is understood to have been confirmed by the opinions of a large majority of commanding officers of different grades, expressed after practical observation of their effect in the field, and more especially after the break-down of the Bavarian mitrailleuse. These officers are said to have been not only adverse to the introduction of these weapons for field purposes, but to have expressed the feeling that not a single field gun should be withdrawn to make way for the mitrailleuse.

The great objections to its introduction for field service are, that it requires for its efficient employment four horses and at least five men, and that its best range is within rifle range.

After describing the various systems of Kartätschgeschütze, or mitrailleuses, the author gives, as far as is known, the organisation into batteries of the new weapon among the principal European powers. Before taking any steps in this matter, most nations have been naturally waiting to see the *rôle* it would play in the recent war before coming to a decision on the question of organisation; consequently, the information given on this head in the book is incomplete.

With the system of organisation, equipment, &c., in France, the history of the last campaign has made us acquainted.

In England, nothing is at present decided, except that some Gatling guns have been ordered.*

In Austria, in accordance with the Reports of the Military Committee (first half-year, 1871), the War Department has decided to adopt the Montigny system, but has not decided on their distribution, organisation, or equipment.

The Russians have already ordered 15 batteries, which are attached to the 15 infantry divisions in the western part of Russia in Europe, exclusive of the Guards. The system adopted is the Gatling, improved by Gorloff. The battery consists of 10 steel barrels, with the Berdan system of rifling, so as to take the cartridge of that system. The carriage is of iron, and of a new model. 6720 cartridges are carried. The battery is drawn by four horses, the ammunition cart by three horses. Four men are required to serve it.

In Prussia, the captured French mitrailleuses will be utilised for the defence of ditches in caponiers.

The question of their tactical *rôle* is summed up as follows :—

Under any circumstances, we can only expect mitrailleuses to be effective against living objects in the open. So far, they can do no more than small-arms and canister;

* It is believed that their use will be restricted to flank defence in fortresses, and for boat service.—F. C. H. C.

and much less can their effect be compared with that of a shrapnel shell, which can reach the enemy when under cover, or with that of a common shell, which, by its superior power and great destructive action, is effective against a resisting object, and at greater distances.

Not only are mitrailleuses incapable of competing with field artillery as regards the effects produced, and in a duel with the field gun, except perhaps at close quarters, would certainly come off second best, but they require just as extensive and costly an organisation and equipment as field artillery. Of course, if they are moved on the field by men, their tactical *fiasco* ought to be complete.

In comparison with small-arms, mitrailleuses perform, at the best, as well as the corresponding number of infantry, which in a given time can fire the same number of shots, but with this important difference—that during this time the fighting fire of the infantry has been doing work for the *tactical offensive*. (This has been often proved in the case of the Prussians, by whom accuracy of shooting has been brought to such a pitch of perfection.) Now, the mitrailleuse can play no part *in the offensive*, and even in the *absolute defensive* occasions will more frequently present themselves in war for placing a half-company of infantry in a position favourable for their fire, and in which they are at the same time sheltered, than for placing a battery of six mitrailleuses, whose fire in the same time would not be greater in point of the total number of shots.

On these grounds, we mean to say that the introduction of mitrailleuses, especially for field warfare, is not warranted; and that it would be a fatal error to reduce the field artillery (as the French did last year), or to neglect to increase it, in order to organise a corresponding number of mitrailleuse batteries.

But the more fruitful field for its use will be that which the siege of a fortress offers, and particularly in the fortress for direct defence against storming, as flank and caponier pieces for defence of the main ditch. Where we have to deal with living objects without cover in the open, where the length and breadth of the space which is to be swept lies within very narrow limits, and when as heavy a fire as possible has to be concentrated in a minimum of time and space, in this case all the advantages are decidedly on the side of the mitrailleuse.

By substituting in flanks or caponiers the fire from a few mitrailleuses for that of small-arms and canister, the passage of the main ditch would be rendered almost impracticable for an assailant, and at the same time these weapons offer so small a mark, that the port-holes (which are purposely placed low down so as to bring a grazing fire on the ditch) can hardly be hit, much less destroyed, by the besieger's indirect counter batteries—those most dangerous enemies of flank batteries and caponiers.

We are therefore of opinion that the mitrailleuse only plays a comparatively modest and subordinate part in war, and that its real and successful future will be found rather in sieges.

96. A Proposed Plan for Carrying the Detachments with Field Artillery.

(Communicated by Captain S. Penny, R.A.)

1. To increase the length of the axletree-box to double its present length, to enable two men to be carried back to back, as formerly, on the wagon body.

2. To do away with the iron guard at the back of the axletree seats on the new

carriages, it being no longer required; and to increase the iron guard on the outer side in proportion with the box.

3. Stiff leather loops to be fastened on the inner side of the axletree-boxes, to assist the men in retaining their positions whilst passing over rough ground.

Advantages.

1. A simple way of carrying the detachment—No. 1 mounted, No. 9 with the wagon, and three men on the gun-limber as at present; the remaining four are carried in such a manner, that on the gun halting for the purpose of coming into action, these men on dismounting are in their proper places for working the gun.

2. An increased amount of ammunition can be carried, equivalent to the contents of two axletree-boxes per gun.

3. The lid of the axletree-box can be covered with thin iron plate, and should open to the rear; so that on its being raised, it would afford a certain amount of protection to the detachment numbers working in rear of the axletree.

97. "Occasional Papers of the R.A. Institution."

The publication of these papers commenced in June 1858, and was discontinued after about two years.

The greater part of them are contained in a volume which has hitherto been offered for sale at 10s.

Many of the articles in this volume are of permanent value in connection with the science of artillery, but there are others on various subjects of only transient interest, which may now be considered to have lost their value.

The original price, 10s., is consequently more than could now be expected for the volume, and the Committee, at a meeting held 4th April, 1872, having taken these circumstances into consideration, decided that the volume bound in half-calf should in future be sold at 5s.

Among the papers of permanent interest in the volume, may be mentioned one by Capt. A. Noble, late R.A., "On the Application of the Theory of Probabilities to Artillery Practice," which, it is believed, was the first successful attempt to utilise the mathematical theory of probability in the comparison of the accuracy of shooting of two or more guns.

98. "Rough Rules for Gunners."

Captain Strange's card containing "Rough Rules for Gunners" is now out of print, and is besides in some respects behind the times with regard to the information afforded.

Captain Strange has been informed, and requested to re-cast the card in such a manner as to accord with the latest regulations. Notice will be given when it is ready for re-issue.

99. List of Service Ordnance and Ammunition.

A revised copy of this table, in which the list of service fuzes recently issued to members has been embodied, and a table of energies and velocities at various ranges of the projectiles of all heavy armour-piercing guns added, is issued with the present number.

GENERAL ABSTRACT

OF THE

INCOME AND EXPENDITURE OF THE ROYAL ARTILLERY INSTITUTION,

From 1st April, 1871, to 31st March, 1872.

EXPENDITURE.

		£	s.	d.	£	s.	d.
Printing	Wages	145	15	2			
	Paper	292	3	10			
	Type and Materials	85	7	7	579	12	1
	Woodcuts	36	16	6			
	Lithography	8	19	0			
	R.A.I. Prize Essay	10	10	0			
Chemistry					5	4	6
Photography					174	12	2
Classes	Drawing	40	0	10	52	0	10
	Italian	12	0	0			
Lectures					51	19	0
Taxidermy					12	0	6
Library, and Books for Sale					283	15	11
Museum					84	2	0
Instruments					51	2	10
Carpenter	Wages	18	15	4	86	12	7
	Materials	67	17	3			
Furniture and Repairs					137	12	1
Subscriptions to Societies					5	0	0
Stationery					116	17	9
Postage and Parcels					53	10	9½
Incidental					49	14	9
Wages to Clerks and Orderlies					125	0	0
War Office Photographs and Lithographs					48	7	7
Premium for Fire Insurance of £5000					12	10	0
Transfer of £1686 5s. 7d. Consols Stock					1	1	1
Powers of Attorney for Transfer and Dividends on Consols Stock					1	19	6
Cash in hand, 31st March, 1872,	Secretary	22	2	5	23	17	2
	Messrs. Cox & Co.	1	14	9			
					£1956	13	1½

INCOME.

		£	s.	d.	£	s.	d.
Cash in hand, 1st April, 1871					2	12	1½
Printing		219	9	7	229	19	7
R.A.I. Prize Essay		10	10	0			
Chemistry					0	1	0
Photography					105	13	10
Classes	Drawing	24	6	0	29	12	8
	Italian	5	6	8			
Taxidermy					10	7	0
Books sold					155	17	1
Carpentry and Wood					27	8	8
Subscriptions	Entrance	60	0	0			
	For 1871–2	1040	3	6	1124	9	0
	For 1872–3	24	5	6			
Stationery					154	17	2
Postage and Parcels					29	8	5
Incidental (Sale of Waste Paper)					2	0	6
War Office Photographs and Lithographs					34	19	7
Dividend on £1686 5s. 7d. Consols Stock					49	6	6
					£1956	13	1½

DEBTOR AND CREDITOR ACCOUNT, 31st MARCH, 1872.

Dr.

	£	s.	d.
By Accounts with:—			
Mr. J. Gould, for "Birds of Australia"	90	15	0
Controller, Royal Arsenal	0	4	0
Balance Creditor	2096	2	4
	£2187	1	4

Cr.

		£	s.	d.	£	s.	d.
Balance Cr.	Cash in hand	23	17	2	1575	4	8
	Consols Stock (at 92)	1551	7	6			
Value of Stock.	Books for Sale	25	0	0			
	Stationery	15	0	0			
	Printing Paper	28	4	0	303	1	2
	"Handbooks" (unbound)	108	0	5			
	"Kane's Lists" do.	106	16	9			
	Chemicals in Laboratory	20	0	0			
Owing by Members and others for	"Kane's Lists"	8	15	6			
	"Handbooks"	47	17	6			
	Printing	42	18	7			
	Chemistry	0	5	8			
	Photography	47	11	7			
	Classes	0	6	4	308	15	6
	Taxidermy	4	10	6			
	Books	66	2	10			
	Carpentry and Wood	4	17	1			
	Annual Subscriptions	36	11	0			
	Stationery	28	14	1			
	Postage	19	1	2			
	War Office Photographs, &c.	1	3	8			
					£2187	1	4

Examined and found correct,

T. J. MACLACHLAN, Capt. R.H.A., & Bt.-Lt.-Col., President Sub-Committee.

R. W. HAIG, Major R.A., Secretary and Treasurer.

WOOLWICH, April 26, 1872.

ANNUAL REPORT

AND

ABSTRACT OF PROCEEDINGS OF A GENERAL MEETING OF THE ROYAL ARTILLERY INSTITUTION, HELD ON MAY 28, 1872.

COLONEL J. W. DOMVILLE, R.A., IN THE CHAIR.

1. The Committee of the Royal Artillery Institution has the honour to present to the Annual General Meeting its Report and the Abstract of Accounts for the year ending 31st March, 1872.

It will be seen by the following table that during the past year 55 officers have joined the Institution; and, after allowing for casualties caused by deaths, withdrawals, &c., there appears to be a net decrease of 12 members. This decrease, however, is not real, as since the 1st April 36 members have joined, making an actual increase of 24. Four additional honorary members have been elected by the Committee.

Rank.	1st April, 1871.	Additions.				Total additions.	Deductions.							Total deductions.	31st March, 1872.
		Promotion.	Retirement.	From retired list.	New members.		Promotion.	Retirement.	To effective list.	Resignation.	Withdrawal.	Names written off.	Deaths.		
EFFECTIVE LIST.															
General and Regimental Field Officers	193	25	—	—	1	26	—	3	—	—	1	—	6	10	209
Captains	455	49	—	3	6	58	25	24	—	—	—	—	1	50	463
Lieutenants	529	—	—	1	39	40	49	13	—	5	1	9	5	82	487
Paymasters	7	—	—	—	1	1	—	1	—	—	—	—	—	1	7
Quarter-Masters	8	—	—	1	—	1	—	—	—	—	—	—	2	2	7
Riding-Masters	5	—	—	—	1	1	—	—	—	—	—	—	—	—	6
Surgeons-Major	5	2	—	—	1	3	—	—	—	—	—	—	—	—	8
Surgeons	3	—	—	—	—	—	2	—	—	—	—	—	—	2	1
Assistant-Surgeons	15	—	—	—	2	2	—	—	—	—	—	—	—	—	17
Veterinary Surgeons	5	—	—	—	—	—	—	—	—	—	—	1	—	1	4
RETIRED LIST.															
General and Regimental Field Officers	62	—	3	—	—	3	—	—	—	—	—	—	1	1	64
Captains	44	—	5	—	—	5	—	—	3	—	—	—	1	4	45
Lieutenants	6	—	3	—	—	3	—	—	1	—	—	—	—	1	8
Surgeons-Major	2	—	—	—	—	—	—	—	—	—	—	—	—	—	2
Assistant-Surgeon	1	—	—	—	—	—	—	—	—	—	—	—	—	—	1
Chaplain	1	—	—	—	—	—	—	—	—	—	—	—	—	—	1
Quarter-Master	1	—	—	—	—	—	—	—	1	—	—	—	—	1	—
Honorary Members	43	—	—	—	4	4	—	—	—	—	—	—	—	—	47
Total	1385	76	11	5	55	147	76	41	5	5	2	10	16	155	1377

2. The Committee is glad to inform the meeting that the financial condition of the Institution is sound and satisfactory.

3. *Printing and Publication.*—Vol. VII. of the "Proceedings" has been completed, comprising the papers enumerated in the following list.

The number of foreign military pamphlets (chiefly German), of great interest, of which translations have been offered for publication in the "Proceedings," has induced the Committee to publish them separately from the "Proceedings." The interest and importance attached to these pamphlets render their publication indispensable, but their presence in the "Proceedings" would tend very much to diminish the value of the latter as a collection of original articles. For many of these translations, the thanks of the Institution are due to Captain W. J. Brancker, R.A., and Lieuts. H. W. L. Hime, R.A., H. R. G. Craufurd, R.A., F. E. B. Loraine, R.H.A., and D. F. Jones, R.A.

The entire absence from the "Proceedings" in future of translations will tend to diminish their usual bulk, and members are therefore invited to increase their exertions to obtain original papers on subjects of professional interest.

List of "Proceedings" printed during the year.

The Minor Tactics of Field Artillery. By Lieut. H. W. L. Hime, R.A. The R.A. Institution Prize Essay of 1871.

A few Notes on the Handling of Horse Artillery and Cavalry. By Captain I. Ketchen, R.H.A.

The Prussian Mode of Conducting Large Manœuvres. A Lecture delivered at the R.A. Institution, Woolwich, February 7, 1871, by Lieut.-Colonel E. W. Bray, 4th King's Own Royal Regiment of Infantry.

Tables of Remaining Velocity, Time of Flight, and Energy of various Projectiles, calculated from the results of experiments made with the Bashforth Chronograph, 1865–1870. By the Rev. F. Bashforth, B.D., Professor of Applied Mathematics to the Advanced Class, Royal Artillery.

Development of Artillery Missiles during 1870. By Capt. C. O. Browne, R.A., Captain Instructor, Royal Laboratory. A Paper read at the R.A. Institution, Woolwich, January 31, 1871, to supplement the Paper on Rifled Shells and Fuzes read by Capt. C. O. Browne, March 8, 1870.

The Determination of the Explosive Force of Gunpowder. A Paper read at the R.A. Institution, Woolwich, March 15, 1871, by Capt. J. P. Morgan, R.A.

Breaching by Indirect Fire. By Colonel H. H. Maxwell, R.A., Superintendent Cossipore Gun Foundry.

Extracts from Major Kodolitsch's Report on the Abyssinian Expedition. Translated from the German by Lieut. Douglas F. Jones, R.A.

The Mobility of Field Artillery; Past and Present. By Lieut. H. W. L. Hime, R.A. (No. III.)

Remarks with reference to Mobility of Light Field Artillery. By Lieut.-Colonel G. Carleton, R.A.

The Clock Signal-Vane. By Captain W. L. Yonge, R.A.

The Multiplying Alidade, or Practice Register. By Major A. Innes, Aberdeenshire Artillery Volunteers. (Communicated by Lieut.-Colonel C. F. Young, R.A.)

System of Iron-plating a Cruising Ship. By Captain M. Tweedie, R.A.

Entrenchment of Field Artillery. By Captain G. B. Macdonell, R.A.

A Sketch of the Autumn Manœuvres of 1871. By Captain W. S. M. Wolfe, R.A., Brigade-Major, School of Gunnery.

Short Notes on Professional Subjects.

Report of Progress, Committee on Explosive Substances. Jan. 1, 1871.
Explosive Compound. "Lithofracteur."
Hydraulic Lifting Jack.

The "List of Service Ordnance and Ammunition" has been rearranged, to admit an additional table of the service fuzes, and another giving the velocities and energies of the projectiles of various guns at different ranges.

Since the last meeting, the Committee directed that letters should be addressed to the Editor Österreichische Militärische Zeitschrift, to the President of the Technischen & Administrativen Militär-Comité, and to the President of the Wissenschaftlichen Vereins, all at Vienna, inviting them to exchange publications with the Institution. Favourable replies have been received to all three invitations, together with the current numbers of the publications issued by each respectively.

The Committee considers these exchanges a matter for congratulation. Not only do the "Proceedings" enjoy a more extended circulation among appreciative readers, but much valuable and interesting information is placed at the disposal of the Institution in the publications received in exchange for the "Proceedings."

A complete set of the "Proceedings" has been presented to the Netherlands Royal Military University at Breda, whence in return have been received a topographical atlas on a large scale of the Netherlands, together with copies of the books, drawings, &c., containing the course of military instruction pursued at the University.

With regard to the prize essay mentioned in last year's Report, six essays have been received and submitted to the referees—viz., Maj.-Gen. E. M. Boxer, F.R.S., Maj.-Gen. H. Clerk, F.R.S., and Colonel Wray, C.B., R.A. The referees having been unable to come to a satisfactory conclusion with regard to three of the essays, Lieut.-General F. M. Eardley-Wilmot, F.R.S., was elected by the Committee to act as arbitrator, and these three essays are still in his hands, a sufficient time not having elapsed to allow of his forming an opinion. The motto of the successful essay and the name of its author must therefore appear in the Annual Report of the Committee for next year.*

4. *Library.*—The Committee is of opinion that the thanks of the members of the Institution are due to Lieut. H. Geary, R.A., for the great care and trouble bestowed by him on a catalogue of the Library which he has drawn up, and which was much required.

This catalogue is now being printed, and will soon be in the hands of members.

The following is a list of presentations to the Institution during the year:—

Books, &c., presented.

Proceedings of the Institution of Mechanical Engineers, Jan., April, July, and Oct. 1871	4	The Council, Institution of Mechanical Engineers.

* The arbitrator decided in favour of the essay bearing the motto "Fortes pejoraque passi," which was ascertained to have been written by Lieut. E. H. H. Collen, R.A., who therefore becomes medallist for the year.

Rifled Cast-iron Ordnance. By Bashley Britten	1	The Author.
Heavy Rifled Ordnance, cast-iron and wrought. By Bashley Britten	1	
Professional Papers of the Corps of Royal Engineers, Vol. XIX.	2	The Editor.
Works published by the Danish Artillery:—		
An Account of the Experiments made by the Artillery, Parts I. to III.	3	Officers of Royal Danish Artillery.
Designs of the New *Matériel* of Artillery	48	
Old Iron Ordnance from 14th to 16th century, Plates 1 to 16	16	
Old Danish Bronze Ordnance, 16th to 18th century, Plates 1 to 27	27	
Proceedings of the Royal Geographical Society, Nos. 1, 2, 3, Vol. XV., No. 1, Vol. XVI.	4	The Council, Royal Geographical Society.
Brief Notes on Field Artillery. By an Officer, Royal Artillery	1	Anonymous.
Meteoric Theory of Saturn's Rings. By Lieut. J. A. S. M. Davies, R.A.	1	The Author.
Observations on the Influence that Arms of Precision have on Modern Tactics. By Field Marshal Baron von Moltke. Translated from the German by Lieut. H. R. G. Craufurd, R.A.	1	The Translator.
Journal of the Royal United Service Institution, No. 61 (Vol. XIV.), Nos. 62, 63, 64, and 65 (Vol. XV.)	5	The Council, Royal United Service Institution.
Treatise on the Art of War	1	
Pleydel's Fortification	1	
Schomburgh on British Guiana	1	
Colonial Statistics	1	
The Hudson Bay Territories	1	
Notes on Defence by Submarine Mines. By Major R. H. Stotherd, R.E.	1	School of Military Engineering, Chatham.
The Construction of Wrought-iron Bridges	1	
Instruction in Photography. By Lieut. Abney, R.E.	1	
Short Notes on Field Batteries. By Capt. C. O. Browne, R.A. Parts 1 and 2	2	The Author.
Proceedings of Scientific Meetings of the Zoological Society of London, for 1871. 4 Parts	4	The Council, Zoological Society of London.
The Defensive Policy of Great Britain. By Col. W. F. D. Jervois, C.B., R.E.	1	The Author.
Notes on the Operations round Shanghai in 1862–64. By Colonel C. G. Gordon, C.B., R.E.	1	Colonel S. E. Gordon, C.B., R.A.
Chinese Work on Artillery, taken at Chanchufoo by Colonel C. G. Gordon, C.B., R.E., and a Chinese Official Envelope, addressed to Col. Gordon.	2	

Russian Artillery Journal for 1870, in 8 Parts	8	General N. de Novitzky.
Russian Small-Arm Journal, Nos. I., II., and III., of 1871	3	
On the Prehistoric Remains in Brittany. By Lieut. S. P. Oliver, R.A.	1	The Author.
The Dolmen Mounds and Amorpholithic Monuments of Brittany. By Capt. S. P. Oliver, F.R.G.S., R.A.	1	
The Manufacture of Russian Sheet-iron. By John Percy, M.D., F.R.S.	2	The Author.
Dictionnaire Franco-Norman		Major-General C. Scott.
Two Copies of Map of North Kent from Ordnance Survey Map	2	Lt.-Col. R. Biddulph, R.A.
Smithsonian Contributions to Knowledge Vol XVII.	1	The Council, Smithsonian Institution.
„ Report, 1869	1	
Congressional Directory for the third Session of the forty-first Congress of the United States of America	1	The President, United States.
Appendix to Benj. Anderson's Journey to Musado	1	Rev. E. W. Blyden.
Notes on the Antechamber of the Great Pyramid. By Capt. H. A. Tracey, R.A.	1	The Author.
On Recent Investigations and Applications of Explosive Agents. By F. A. Abel, Esq.	1	The Author.
Report on Scientific Inventions of a Chemical Nature	1	
Speech delivered in the House of Commons, June 23, 1871, by Major G. Arbuthnot, M.P., R.A.	1	The Author.
A Few Remarks on the Artillery of the Reserve Force	1	Anonymous.
Tables of Remaining Velocity, Time of Flight, and Energy of Various Projectiles, calculated from Experiments made with the Bashforth Chronograph	1	The Rev. F. Bashforth, B.D.
Medals, Clasps, and Crosses, Military and Naval. By Surg.-Maj. Fleming, late 4th Dragoon Guards	1	The Author.
Minutes of Proceedings of the Institution of Civil Engineers for 1870–71, in 2 parts	2	The Council, Institution of Civil Engineers.
Index of the above Proceedings from Vols. XXI. to XXX.	1	
Memoir of Field Marshal Sir John Fox Burgoyne, Bt., G.C.B.	1	
Memoir of Lieut.-General Sir William Denison, K.C.B.	1	
Lead Pencil Copies of two Paintings in the possession of Sir John Gaspard Le Marchant, G.C.M.G...............	2	Captain C. B. Le Mesurier, R.A.
Topographical Map of Mentona	1	
Our Railway System, viewed in reference to Invasion. By R. Mallet, Esq. ...	1	The Author.

Dublin Magnetical and Meteorological Observations, 1844 to 1850	1	Major-General W. J. Smythe, F.R.S.
St. Helena do., 1844 to 1859............	1	
Atlas of the Movements of the Atmosphere, July to December, 1865	1	
Contributions to the Knowledge of Cape Horn and the West Coast of South America	1	
Barometer Manual, Board of Trade	1	
Report of the Meteorological Committee of the Royal Society, 1870	1	
R.M. Academy Regulations, 1871	1	The Governor, Royal Military Academy.
Examination Papers, R.M. Academy, July, 1871, February, 1872	2	
Questions and Answers for Batteries of Horse Artillery. By Lieut. C. H. Thompson, R.H.A.....................	1	The Author.
Treatise on Ammunition, Part II. (*Continued.*)	1	Secretary of State for War.
Meteorological Observations	1	
Instructions for taking Meteorological Observations, with tables for same ...	1	
Reports of Special Committee on Martini-Henry Breech-Loading Rifles ...	1	
Experiments with Montigny and Gatling Mitrailleuse at Shoeburyness	1	
Report of a Committee on the Education of Officers of the Royal Artillery.	1	
Progress Report of the Committee on Explosive Substances	1	
Translation of Report of General Herzog on the Mobilisation of a portion of the Swiss Army in July and August, 1870	1	
Remarks on the Military Organisation of France and Prussia. By Lt.-Col. Reilly, C.B., R.A.	1	
The Elementary Tactics of the Prussian Infantry. Translated from the German by Lieut. E. Baring, R.A.	1	
Regulations for the Training of Troops for Service in the Field, and for the Conduct of Peace Manœuvres. Translated from the German by Lieut. E. Baring, R.A......................	1	
Copy of one-inch Map of Aldershot and vicinity, printed on calico	1	
Copy of Camping Grounds (6-inch scale) of Aldershot and vicinity	1	
R.L. Lithographs	11	
R.G.F. Lithographs	1	
R.C.D. Lithographs	4	
War Office Photographs	82	
Report I., 16-pr. Muzzle-Loading Rifled Field Gun	1	

Plates of the Netherlands Artillery *Matériel*	32	Netherlands Government.
Washington Magnetical Observations, 1840, 2 Vols....	...	Gen. Sir E. Sabine, K.C.B., R.A.
Madras do. do. 6 Vols....	...	
Bombay do. do. 6 Vols....	...	
Belgian do. do.	...	
Russian do. do.	...	
Greenwich Magnetical and Meteorological Observations, 1841 to 1869, 40 Vols.	...	
Makerstown, do., 1844 to 1846, 2 Vols.	...	
Report of the British Association, 1833 to 1870, 33 Vols.	...	
Daily Observations of Magnetometers, 44 Vols.	...	
British Association, Catalogue of Stars...	1	
Zenith Distances Observed with the Mural Circle, 2 Vols.	...	
Transits Observed, 1834	1	
Magnetical Instructions for the Use of Portable Instruments	1	
Instruments for Determining the Magnetical Inclination and Intensity	1	
The Admiralty Manual of Scientific Enquiry	2	
South Africa and its Diamonds. By Professor J. Tennant	1	The Author.
On the Employment of Field Artillery in combination with the other Arms. A Translation from the German, by Captain F. C. H. Clarke, R.A.	1	The Author.
Monthly Return of the Artillery under the command of Colonel Webber-Smith in Portugal, Feb. 1827	1	Lieut. H. W. L. Hime, R.A.
Opinions et Maximes de Frédéric le Grand	1	
Mémoire sur le Lieut.-Général D'Artillerie Baron Alexandre De Senarmont	1	
Essai sur la Tactique des Trois Armes, Isolées et Réunies	1	
Campagne de l'Armée du Nord en 1870-71	1	
La Deuxième Armée de la Loire, par Général Chanzy, et Atlas	1	
Campagne de 1870. Des Causes qui ont Amené la Capitulation de Sedan	1	
La Campagne de 1870, jusqu' au 1st Sept.	1	
Journal d'un Officier de l'Armée du Rhin	1	
Idées et Reflections sur les Movements de la Tactique Moderne	1	
Conferences Militaires Belges	1	
L'Artillerie de Campagne Belge	1	
Preukische Infanterie, 1869	1	

Canada in 1871; or, Our Empire in the West. By Captain F. Duncan, R.A., M.A., &c., &c.	1	The Author.
Defence of Washington. By Maj.-Gen. Bernard, United States Army	1	The Author.
Lord Seaton's Regiment at Waterloo, and Supplement. By Rev. W. Leeke, M.A. 3 Vols.	1	The Author.

MAPS.

Europe.

Military, of part of (4 sheets)

Austria.

Austria and Turkey (3 sheets)
Battle of Koniggrätz, plan of

Denmark.

Jutland (10 sheets)
Sleswig Fastland (10 sheets)
Kort over Als
Frederica, Sketch of Fortress of
Fyen on Funen

Italy.

Venetia, the Country Round

Sardinia.

Sardinia (8 sheets)

Russia.

Fort Bomarsund
Flag-staff Battery
Mamelon Redoubt, outline plan of
Right and Left Attack, Sebastopol (outline)
Right Attack (Plate VII.), to end of Siege
Left Attack (Plate VIII.), to end of Siege

Belgium.

Grand Duchy of Luxemburg

Asia.

Action of the Allied Armies, Sept. 18, 1860
Action at Pa Le Chiao
Operations of the Allied Armies (Allgood)
Pekin and Gulf of Pechili
Pekin, despatches from the Capture of Taku Forts, &c.
Peiho River, Operations on
Weights and Measures, Chinese Table of
Pekin, Plan of
" Description of
" Sketches showing preparations for breaching walls
" Environs
" Country Round
Canton—Plan of City and Suburbs of
Kiakhta to Pekin (3 sheets)
Shanghai and Country Round (2 sheets)

Secretary of State for India.

Maps, Asia (Continued).

Sow Chow, Sketch Map of Country Round ......
Che Kiang, Province of ....
Operations of Allied Armies in China (Brabazon)
Despatches to accompany preceding ....

Japan.

Kagosima, Plan of Bombardment of ....
Yokohama, Plan of ....
Simonosaki, Operations against ....

Africa.

Morocco, Map of, in 2 sheets ....
Abyssinia, Route Map of ....
Magdala, Drawing of ....
" Sketch of Capture of ....
Annesley Bay to Magdala (5 sheets) ....

America.

British Columbia, Plan of Route from New Westminster to Fountamby ....
Vancouver Island, in 8 sheets ....

New Zealand.

Sketches in New Zealand, to accompany Q.-M.-General's Report, 1 to 19 ....
Waikato, Neighbourhood of ($2\frac{1}{4}$ sheets) ....
Rangiriri, Sketch of the Ground and Scene of the Action at ....
Koheroa Ridges, Sketches of Country Round......
Auckland and the Waikato River, Sketch of the Country between ....

India.

Country round Delhi, showing the Camps of Exercise ....
*The Eastern British Frontier ....

} Secretary of State for India.

Books purchased.

Practical Astronomy. Loomis.
The Ibis. Nos. 2, 3, 4, and 5, Vol. II.
Monograph of the Barbets. Parts VII., VIII., and IX.
Todhunter's Algebra.
Practical and Spherical Astronomy. Chauvenet.
Monograph of the Pheasants. Parts III. and IV.
Sharpe's Birds of Europe. Parts IV., V., VI., VII., VIII., and IX.
Grammatica Celtica. Parts I. and II.
English-German, and German-English Dictionary.
Regulations and Instructions for Encampments.
Treatise on Ambulances. Longmore.
The Soldier's Pocket-Book for Field Service. Wolsley.
Manual of Field Fortification, Military Sketching, and Reconnaissance.
Gould's Birds of Great Britain. Nos. 19 and 20.
Elements of Mechanism. Goodeve.
Organic Chemistry. Miller.
Algebra and Trigonometry. Griffin.

Elements of Geometry. Watson.
Bewick's British Birds. Two Vols.
Our Iron-clad Ships. E. F. Reed.
The System of Attack of the Prussian Infantry.
Vesey's Questions and Answers on Artillery Subjects.
Schellen's Spectrum Analysis.
The Austrian Campaign of 1866.
Révue Militaire Française, 1870.

5. *Museum.*—A list of the presentations to the Museum is attached to this Report.

During the past year the following additions have been made to the natural history collection—viz., a very interesting collection of birds, from Jamaica; also a small collection of land shells, from the same locality, by Colonel Desborough, R.A.; a few specimens of birds from India, America, and Bermuda, by Lieut. Turner, R.A., Lieut. Baddeley, R.A., Lieut. A. G. Yeatman, R.A., and Lieut. Gaimes, R.A.; a few British birds, by Captain J. S. Stirling, R.A., amongst which is a very fine male specimen of capercailzie; and a fine pair of horns of the sambur, and also a small pair of moose horns, by Captain T. B. Strange, R.A. A few British birds have also been purchased, thus slightly reducing the long list of specimens required to complete the Institution collection, of which a copy will be found in last year's Report.

Presentations to Museum.

Prussian Time Fuze, picked up on the field of Gravelotte	1	Captain H. Burgess, R.A.
British Birds	4	Captain J. S. Stirling, R.A.
A very fine specimen of Vertebræ of the Iguandon, from the Wealden formation, Brook Point, Isle of Wight	1	Lieut. C. Jones, R.A.
An Old Horse Artillery Helmet worn by the late Lt.-Gen. Webber-Smith, C.B., during the Peninsular War; and a Sword worn by the late Maj.-Gen. Sir A. Dickson, G.C.B., when Brigade-Major of the Royal Artillery in Portugal in 1809	2	Colonel E. F. Grant, R.A.
Buffalo Horn for holding powder, taken from Riel, the usurping President of Red River	1	Lieut. H. P. P. Leigh, R.A.
Specimen of the Black Skimmer, from River Plate, South America	1	Captain E. L. Bland, R.E.
Type Specimens of Birds	10	Mr. H. Whitely, sen.
Type Specimens of Birds, from South America	6	
A Photograph of the Cemetery, Simla, showing the grave of the late Sir George Barker, K.C.B., Colonel Royal Artillery	1	Surg.-Maj. J. M. S. Fogo, R.A.
Telescope formerly belonging to Lieut.-General Sir W. Congreve, Bart., R.A.	1	Col. S. E. Gordon, C.B., R.A.

Tails of Lyre Birds	4	Captain W. A. Warren, R.A.
Specimen of Malachite	1	Captain W. A. Warren, R.A.
Piece of Quartz, containing gold	1	Captain W. A. Warren, R.A.
Birds from India	2	Lieut. F. M. Turner, R.A.
Moth Specimen	1	Lieut. J. S. Quayle, R.A.
Birds from Jamaica........................	35	Colonel J. Desborough, R.A.
A Collection of Shells from Jamaica ...	...	Colonel J. Desborough, R.A.
Specimen of Ornithorynchus	1	Major A. Strange, 14th Regt.
Birds from Bermuda	4	Lieut. H. F. Gaimes, R.A.
Specimen of Copper Ore from South America	1	Captain J. F. Owen, R.A.
Specimen of Kunkur, used in the construction of the roads in India, and of the same substance as washed out in the Pugging Mill at Shoeburyness	2	Col. S. E. Gordon, C.B., R.A.
Birds from America	3	Lieut. A. G. Yeatman, R.A.
Ammunition for the new Bavarian rifle, April 1871, in various stages of manufacture	...	Capt. E. H. Cameron, R.A.

Birds from Jamaica, presented by Colonel Desborough, R.A.

Merula leucogenys.
Mimus polyglottus.
Tyrannus dominicensis.
" "
" caudifasciatus.
Vireosylva olivacea.
Vireo noveboracensis.
" "
Myiobius tristis.
" pallidus.
Todus viridis.
Setophaga ruticilla.
" "
Seuirus aurocapillus.
" "
" "
Trichas marylandica.
Sylvicola canadensis.

Sylvicola pensilis.
" "
Parula americana.
Mniotilta varia.
" "
Certhiola flavecola.
Ceryle alcyon.
" "
Tanagrella ruficollis.
" "
" "
Quiscalus crassirostris.
Pyrrhula violacea.
Spermophila olivacea.
" "
Chamæpelia passerina.
" "

Also a small collection of land shells.

Birds from Scotland, presented by Captain J. S. Stirling, R.A.

Hydrobata cinclus.
Tetrao urogallus. ♂

Charadrius pluvialis.
Gallinula chloropus. ♂

Birds from Canada, presented by Lieut. Yeatman, R.A.

Limosa hudsonica.

Somateria mollissima. ♀

From Barbadoes.

Strepsilus interpres.

From India, presented by Lieut. Baddeley, R.A.

Hydrophasianus chirurgus.

Birds from Bermuda, presented by Lieut. Gaimes, R.A.

Silia sialis. ♂
" " ♀
Cardinalis virginianis. ♂
" " ♀

Birds from India, presented by Lieut. Turner, R.A.

Scops lettia.
Pterocles fasciatus.

By Captain Bland, R.E., from South America.

Rynchops nigra.

From Australia, presented by Captain Warren, R.A.

Four tails of manura superba, or lyre bird.

British Birds Purchased.

Otis brachyotus.
Stux flammea. ♂ ♀
Anthus richardii. ♂
Turdus torquatus. ♂ ♀
Nucifraga caryocatactes. ♂
Corvus Corax. ♂
Strobilophaga enucleator. ♂ ♀
Loxia leucoptera. ♂
Picus major. ♀
Dryocopus martius.
Otis tetrax. ♂ ♀
Glareola pratincola. ♀
Ardea minuta. ♂
Ibis falcinellus. ♂
Numenius phæopus. ♂
Limosa lapponica. ♂
Recurvirostra avocetta. ♂
Himantopus candidus.
Tringa canutus. ♂
" maculata. ♂
Gallinago major. ♂
Phalaropus fulicarius ♂ ♀
Fulica atra. ♂
Tadorna vulpanser. ♀
Chaulelasmus strepera. ♂
Clangula glaucion. ♂
Mergus Castor. ♂
Uria grylle. ♂ ♀
Arctica alle. ♂
Thalassidroma leachii. ♂
Lestris parasiticus. ♂ ♀

Presented by Captain T. B. Strange, R.A.

Horns of Rusa equina (sambur).
Horns of Alces americanus (elk or moose.)

Birds from South Africa, South America, Java, Australia, and New Guinea, presented by H. Whitely, Sen.

Micraster rupicollis.
Milvago megalopterus. ♂ ♀
Scops leucotis.
Dendrochelidon klecho.
Irrisor erythrorhynchus.
Macronyx capensis.
Pteroglossus aracari.
Pyrosterna flavirostris.
Selenidera maculirostris.
Ramphastos tucanus.
Chrysotis amazonica.
Melanerpes cruentatus.
Scythrops novæ hollandiæ.
Ptilinopus swainsonii.
Synoicus australis.

By the late Major A. Strange, 14th Regt., through Captain T. B. Strange, R.A.

Platypus (Ornithorynchus rufus).

6. *Classes.*—Classes for Drawing have been well attended, as well as those for French and German connected with the Department of Artillery Studies. Four officers have also received instruction in Italian during the year.

7. *Observatory.*—A great portion of the building of the Observatory —viz., three of the principal rooms—has been for many years lent to General Sir Edward Sabine, late President of the Royal Society, &c., as an office for collating and discussing the records of magnetic observations in various parts of the world.

The purchase of the equatorial telescope decided upon last year rendered it necessary to ask for the re-occupation of these rooms, which are now again at the disposal of the Institution. One of them has been furnished with a view to its being a sitting and waiting room for members using the astronomical instruments. This room being already furnished with a book-case, it has been thought desirable to transfer to it from the library of the Institution all works bearing on the subject of astronomy. On giving up this portion of the Observatory, General Sir E. Sabine has presented the Institution with a large number of valuable scientific books, which will be found enumerated among the list of presentations before referred to.

With regard to the telescope, the Sub-Committee selected to consider the best means of procuring it, after due deliberation and consideration of estimates, decided upon obtaining it from Mr. J. Grubb, of Dublin, with whom a contract was made, binding him to erect the telescope in the Observatory in such a manner as to satisfy the judgment of Mr. Warren De la Rue, F.R.S., &c., who has kindly undertaken to examine the instrument throughout, and favour the Institution with his opinion thereon. This disinterested kindness on the part of Mr. De la Rue calls for the thanks of the members of the Institution.

8. *Photography.*—The photographic department having been reported in an unsatisfactory condition last year, a Sub-Committee was appointed to consider the subject.

On their recommendation, the services of Mr. Cobb, a professional photographer, were secured, and after a preliminary trial of some five months, an engagement was entered into with him for a period of one year, beginning from 1st January, 1872, after which one quarter's notice is to be given by either of the contracting parties. After the preliminary trial, during which the Committee had every reason to be satisfied, both with the work and attention of Mr. Cobb, the expenditure and receipts were examined, and as it appeared probable that the Institution would gain rather than lose by the terms made with him, the engagement above mentioned was entered upon.

Members can now have photographs taken throughout the week from 10 a.m. till 3 p.m., except on Wednesdays and Saturdays, when the photographic room is reserved for the practice and study of photography by members after 1 p.m.

9. *Chemistry.*—The laboratory has been in use during the year by classes under the Director of Artillery Studies.

10. *Instruments.*—The instruments are in working order. A large condensing lens and a pair of bisulphide of carbon prisms have been added to the apparatus in connection with the electric lamp purchased last year.

11. *Model Room.*—The patterns of service ammunition and other stores have been changed and renewed from time to time, as alterations have been authorised by the War Department, so that members may have before them only the most recently approved patterns.

12. *Workshop.*—The shop is in good working order, and has been made use of by members, besides being constantly in use by the carpenter of the Institution.

13. *Lectures.*—The following lectures have been delivered during the winter in the Theatre of the Institution, and were generally very well attended. The Committee has to express its thanks to Canon Kingsley, Mr. S. Brandram, Captain F. Duncan, R.A., and Dr. Hogg, for their kindness in devoting so much time to the advantage of the Institution.

Of the course of six lectures on Geology, by Mr. Etheridge, three had been delivered previous to the Annual Report for last year, and the remaining three subsequently.

Canon Kingsley	"The Study of Natural History."
Captain F. Duncan, R.A., M.A., D.C.L., &c., &c.	"How a Gunner Governed New York.—A Chapter in the History of the Royal Artillery."
S. Brandram, Esq., M.A.	Readings from various authors.
Rev. J. B. Owen, M.A., F.S.A.	"Superstitions: Social, Political, and Religious."
Rev. H. Martyn Hart, M.A.	"Light and Spectrum Analysis" (in two lectures).
Rev. A. J. D'Orsey, B.D.	"The Augustan Age of English Literature."
Asst.-Surg. F. R. Hogg, M.D., R.H.A.	"Sick Children.—An attempt in a popular form to explain certain causes of domestic sickness."

14. *Afternoon Meetings.*—These meetings, confined to the discussion of subjects of professional interest, have been well attended, and the thanks of the Committee are due to the following officers for the papers read by them:—

Captain C. B. Brackenbury, R.A.	"Autumn Manœuvres.
Captain J. Sladen, R.A.	"Flat Trajectories: What are they?"

Both of these papers have been published in the "Proceedings."

15. The following officers have ceased to be members of the Committee, either owing to promotion or to removal from the Garrison. The vacancies occasioned have been filled up by the Committee, subject to the approval of the general meeting :—

Major-General W. J. Smythe,	by	Colonel T. W. Milward, C.B.
Lieut.-Colonel J. S. Tulloh, C.B.,	"	Lieut.-Colonel C. F. Young.
Major H. Le G. Geary,	"	Captain F. Duncan.
Captain C. B. Le Mesurier,	"	" H. C. Farrell.
" H. C. Farrell,	"	Lieut.-Colonel T. J. Maclachlan.

In compliance with Rule V., the following officers retire from the Committee, and are not eligible for re-election :—

Lieut.-Colonel O'B. B. Woolsey.	Major R. Oldfield.
" C. H. Owen.	Captain M. C. Newall.

Captain J. Sladen.

The following officers were elected to serve on the Committee, viz :—

Lieut.-Colonel J. De Havilland.	Captain E. Maitland.
Captain J. S. Stirling.	" M. Tweedie.

Captain J. F. Betty.

The following resolutions were proposed :—

1. *Proposed by the Chairman, seconded by Colonel A. Thompson, R.A., and carried unanimously :—*

"That the Report of the Committee be adopted and printed, and that thanks are due to the Committee."

2. *Due notice having been given, in accordance with Rule XX., the following addition and alteration to the Rules were submitted by the Committee :—*

Addition to Rule II. (printed in italics) :—

"II. Officers of the Royal Engineers, and of the Militia Artillery, and Professors and Masters of the Royal Military Academy, are eligible to become honorary members. They may obtain the periodical publications of the Institution on the annual payment in advance of the sum of 10*s.* 6*d.*

"*Officers in the Army or Navy, or in the Reserve Forces, who are ineligible to become honorary members, may obtain the periodical publications of the Institution on the annual payment in advance of* 15*s*."

Alteration in Rule V. (*printed in italics*) :—

"V. H.R.H. the Field Marshal Commanding-in-Chief to be Patron and President of the Institution. The Inspector-General of Artillery, the Commandant of the Garrison, the Director of Artillery and Stores, and the Deputy Adjutant-General, to be Vice-Presidents. The affairs of the Institution to be under the direction of a Committee, consisting of the *Deputy Adjutant-General, the Director of Artillery and Stores, the Director of Artillery Studies, and seventeen officers elected at the annual general meeting, of whom one may be a General Officer on the unemployed list, and if so, then five others shall be Regimental Field Officers; but if there be no such General Officer on the Committee, then six of the members shall be Regimental Field Officers. There shall also be one Medical Officer. The senior officer present to take the chair. The Medical Officer to retire every two years. Two General or Field Officers and three members to retire annually by rotation, and none of these to be eligible for re-election until the expiration of one year after leaving office.*"

The addition to Rule II. was carried unanimously, but the words "*at the discretion of the Committee*" were, at the recommendation of the Chairman, inserted between the words "may" and "obtain."

On the question of the proposed alteration to Rule V., the Chairman requested that his dissent might be recorded, and it was moved by Lieut. H. D. Dunlop, and seconded by Lieut. Riall, "that Rule V. shall remain as at present." This was negatived, and the original proposal was then put and carried.*

3. *The following proposition was then put by the Committee, and carried unanimously* :—

"That, taking into consideration the active part taken by them in the foundation of the Institution, and the anxiety for its welfare and best interests which they have at all times evinced, the following officers be invited to become perpetual Vice-Presidents of the Institution, viz.:—

Major-General F. M. Eardley-Wilmot, F.R.S.
" W. J. Smythe, F.R.S.
" J. H. Lefroy, F.R.S."

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* At subsequent meetings of the Committee of the Institution, held on July 29 and August 8, 1872, a correspondence which had taken place between the Committee and the Commandant of the Garrison and the Deputy Adjutant-General of the Royal Artillery was read; and in accordance with the order of His Royal Highness the Field Marshal Commanding-in-Chief, the portion of the alteration referring to the removal from the Committee of H.R.H. the Field Marshal Commanding-in-Chief, the Inspector-General of Artillery, the Commandant of the Garrison, and the Assistant Adjutant-General, was cancelled. The Brigade Major, and the Secretary, Department of the Director of Artillery and Stores, were at the same time re-elected to serve on the Committee.

THE ESTABLISHMENT

AND

ORGANISATION OF AN ARSENAL.

BY

LIEUT. E. H. H. COLLEN, R.A.

STAFF COLLEGE, SANDHURST.

THE R.A. INSTITUTION PRIZE ESSAY OF 1872.

"Fortes pejoraque passi."

In the bright light which the spirit of our times throws upon all matters touching the profession of arms, we may expect to see those paths of military administration which are clear to the few and obscure to the many lit up and thrust into bold relief.

Up to a date not very remote, but little attention was paid in this country to a study of the principles of organisation, and the methods of supply, the best adapted to the British army. Just as at one time the highest idea of tactics was "to go straight on and beat the enemy," so in administration the methods of supply were, good or bad, very much dependent upon the degree of ability possessed by the fighting leader.

This epoch of our military history is now passing away; the system of administration must gradually settle, and assume some permanent form adapted to our national characteristics and the varied requirements of our service. The time has passed when we could assert that pluck and money would pull us through every kind of danger and emergency. Modern warfare admits of no delay, allows no time to a nation prostrated by a heavy blow to recover its strength. Every combination of danger must be provided against, every phase of battle practised, every difficulty of supply prepared for. The day has gone when we could point proudly to a great commander to combat every foe by turn, to remedy every evil of administration. "The Duke of Wellington was a *system in himself*, and when he left us, he left us without a system." It is, then, the task of the soldiers of the present day, each in his own sphere, to try and work out the many questions which must be solved, and to assist in the building up of our system of military administration upon a sure foundation.

If, then, it may be conceded that the time is fast approaching when the soldier who aims at distinction must understand and appreciate every part of the great machine by which an army is worked, I may hope to attract to the subject of this essay the attention of those who would pass it by as not concerning the active duties of their profession, and as a matter that might well be left to the few who have made this branch of the artillery service the business of their lives. It requires, however, but little consideration to show how deeply and intimately is connected the duty of supply with those military operations which form the chief study of soldiers. Few of us indeed may be called upon actually to organise an arsenal, but still every artillery officer should consider the principles which should govern the working, while our brother officers of other branches of the service will not find it vain and unprofitable labour to look into a matter which may be of deep importance to a general and his staff, whether in the defence of this country or in foreign expeditions or wars.

The national scheme of military organisation which has been so lately placed before the public, recognises completely that decentralisation in respect to warlike stores, which must accompany an attempt to form a force of the higher tactical units, each complete in itself.*

It has long been a subject of discussion as to whether we ought not to have a central arsenal, and by this means avoid the accumulation in one spot of our military manufactories. Under the new condition of things, however, all our forces will be supplied from local depôts, and it is not unreasonable to hope, that at no very distant time we may possess a central arsenal of construction sufficient to supply, with the assistance of the existent private manufactories, all the wants of an army in the field. Be this as it may, there can be no doubt that, under the new system of army organisation, the General and Staff Officers of those portions of the country which may eventually correspond to army corps, must make themselves so well acquainted with their respective districts and their resources, that in the event of national danger or emergency, they would be able to make arrangements for the construction and manufacture of such warlike stores as would be demanded by an army in the field. However impossible it may be for them to attain that detailed knowledge of construction and supply which long experience alone can give, it will still be incumbent upon the responsible administrating officers to understand and apply the governing principles.

In the colonies, and in India, and in the variety of circumstances of country and climate under which British officers may be called upon to serve, it is not difficult to see how useful a knowledge of organisation may be, whether connected with the supply of *munitions de guerre* or *munitions de bouche*—the two great kinds of food upon which the life of

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* "According to these arrangements, the troops of the reserve would be equipped for either of the foregoing objects in respect to arms, accoutrements, clothing, or expense ammunition from the depôt centres; the regular and reserve forces both obtaining camp equipage, field stores, and reserve ammunition from the district issuing store."—Report on the Organisation of the various land Military Forces of the Country, by a Committee assembled by order of the Secretary of State for War.

an army is nourished and supported. Nor is it a small thing that the combatant officers of the army of all classes should understand the process of administration, and be able to appreciate the difficulties of supply. The harmonious working of all branches and departments of the army can only be attained by mutual knowledge and mutual dependence; by a strong check being put on the tendency to regard one's own branch as the only part of the great machinery to be taken care of. Unless this check be applied, not by outside regulations, but in our own ideas and habit of thought, then this inevitable result follows —the machine is thrown out of gear, because we are trying to work one part at the expense of the remainder, and we realise what is meant by disastrous administration, by the "organisation of defeat."

In treating this large subject it may be as well to lay down the order generally in which it may be dealt with, and it will be convenient to detail the order in this place, viz.:—

1. The definition of an arsenal.
2. The circumstances under which an arsenal may be established.
3. The considerations which govern the position of an arsenal.
4. The general principles of the organisation of an arsenal.
5. The details of the organisation of an arsenal, divided under three heads, viz.:—

A. Storekeeping.
B. Construction.
C. Administration.

1. The Definition of an Arsenal.

An arsenal is an establishment for the construction, repair, receipt, storage, and issue of warlike stores.

Arsenals may be divided into two classes—

First-class arsenals,
Second-class "

In first-class arsenals, every want of an army and the military service* in respect to munitions of war must be provided for. An army requires guns of many kinds, and all the innumerable appliances connected with keeping these weapons in order, their service, and repairing them when damaged. It requires wood and iron carriages for the guns, hundreds of stores connected with guns, their carriages, and their service, as well as transport carriages of all kinds. It requires projectiles—shot, shell, incendiary and miscellaneous, including rockets; varieties of charges for firing the guns, or for bursting the projectile; the means of igniting these charges—as tubes, portfires, &c.; the means of igniting the bursting charges—as all the varieties of fuzes. An army must be

* And in certain cases, of the naval service also.

supplied with all kinds of small-arms, including rifles, carbines, pistols, swords, bayonets, lances; all the implements used in connection with these arms, and the necessary cartridges for the rifles, carbines, and pistols. It must be supplied with entrenching tools, and, indeed, tools of every description; all kinds of engineer requirements, including pontoons, military railway construction materials, telegraph materials, &c. An army requires harness and saddlery, and all sorts of accoutrements, and in our service a vast quantity of camp equipment. Lastly, it requires such tools and materials as will enable its artificers to keep everything in repair.

In this imperfect summary of the requirements of an army, I have necessarily excluded those necessities which rather come under the head of clothing and *munitions de bouche*.

These requirements of an army, therefore, demand the following establishments in a first-class arsenal of construction and store, in addition to great storehouses:—

1. Gun Factories.
2. Carriage Department.
3. Laboratory.
4. Small-arms Factory.
5. Harness, Saddlery, and Tent Factories.
6. Powder Factory. (This latter, however, being removed from the arsenal itself, but connected with it in the matter of administration.)

Second-Class Arsenal.

In an arsenal of the second class, the great manufacturing establishments of the first-class arsenal are compressed into workshops for partial construction and for repair, the store department being of equal magnitude and importance with that of the first-class arsenal. Provision must, however, be made for manufacture, to a limited degree, so that by the judicious position and arrangement of our arsenal, we may be prepared to utilise the manufacturing resources of the district in time of pressure or danger.

With the construction of guns, and the various elaborate processes to which the metal is subjected before being placed in the hands of the artilleryman, a second class arsenal is hardly concerned, although its workshops must be adapted to perform certain minor operations connected with ordnance.

While it would be necessary to provide for the chief kinds of ammunition used for field purposes, it would not be possible to have such an establishment as would suffice to manufacture the numerous varieties of ammunition required for siege and naval purposes.

Again, while the second-class arsenal in peace time would be unable to turn out large batches of carriages, it should be able to make and repair gun-carriages and other carriages used in the field, and form the nucleus of a larger establishment for this purpose. In addition, the second-class arsenal should possess workshops for the repair of small-arms, and for the manufacture on a limited scale of harness, saddlery, and accoutrements.

2. The Circumstances under which an Arsenal may be Established.

The foregoing definition does not pledge us to an acceptance of the principle that one division of labour is of more importance than another in constituting an arsenal; nor should it do so, for the circumstances are varying under which an arsenal may be established, and no absolute rule can be laid down to govern every case.

The following appear to be the general divisions of this branch of the subject. We may have to establish an arsenal in—

(1) England.
(2) India.
(3) The Colonies.
(4) A foreign country, during a war with that country.
(5) A foreign country inhabited by a savage nation, as in an expedition against that nation.

In the first case, an arsenal might consist of establishments for manufacture, and for storage of munitions of war.

In the second case, it would probably consist of large establishments for storage, with small factories or workshops for repair and replacement.

In the third case, large establishments for storage, combined with the adaptation of any existing factories to the manufacture of such munitions of war as could be made in the country.

In the fourth case, as our base of operations would usually be on the sea, we should rarely be able to secure the advantages of the factories of the country situated at the centres of population, and the arsenal would generally become an extensive depôt.

In the fifth case, also, the storage of munitions of war and the formation of a field arsenal would be the primary considerations.

In considering the nature of the arsenal we should desire to establish in England, I think it must be assumed that the grand factories at Woolwich, whose organisation and superintendence have received no small meed of approbation from the highest authorities of this and other countries, can form no absolute example to the military administrator. In the Royal Arsenal at Woolwich are comprised vast ranges of works which no state could afford to reproduce and support in a second locality. The Royal Gun Factories, the Royal Laboratory, and the Royal Carriage Department are establishments we may desire to transfer to some more secure part of the kingdom, but whose splendid scale we cannot hope to imitate.

In the establishment, therefore, of an arsenal in England, my remarks will apply chiefly to a second-class arsenal, or "great military depôt, in which a certain amount of military stores should always be preserved, in order that the country may not be deprived of its military resources in the event even of Woolwich falling into the hands of an enemy, and which may also be used temporarily, to a certain extent, as an arsenal of construction on an emergency; or, at all events, as a place for the

reception or fitting of such *matériel* as may be furnished by the neighbouring workshops."*

In India, the natural bases of supply are found at the great ports and capitals—viz., Calcutta, Madras, Bombay. Around these are grouped the factories, or within convenient distances;† and the various arsenals necessary for the supply of the fractions of the army scattered over the vast empire, are placed at the secondary bases and strategic points. In this case, also, the duty of an officer charged with the establishment of an arsenal would be confined to the creation of a large military depôt, but provided with workshops for construction to a limited extent, and for repair.

In the colonies and in foreign countries—cases embraced under the third, fourth, and fifth heads (see *ante* p. 109)—we see that the establishments would properly belong to a second-class arsenal. Circumstances, however, might occur in which we might have to establish factories, but the probability is so remote that we must subordinate this branch of the subject to that which appears more likely to occur in actual practice. At the same time, it will be right to touch upon the larger question, however difficult or even impossible it may be to enter into details, concerning which a consideration of the place and time can alone afford a real and practical decision.

3. The Considerations which Govern the Position of an Arsenal.

The position of an arsenal will invariably be governed by strategical considerations.

An arsenal should be situated at the base of operations, whether for offensive or defensive purposes. Jomini draws a distinction between the base of operations and the base of supply, but this distinction cannot apply to the furnishing and replacement of munitions of war. In defensive operations it must be situated near that point which is the best adapted in all respects to form a last stand-point against attack, and from which a successful counter-stroke may be launched at the assailant.

It must be secure from attack, placed at that point from which the transport of stores can be effected with the greatest facility, whether by rail, water, or road—a combination of all three means of transit being the most to be desired—to the various parts of the area to be supplied.

It should never be too near the frontier, or outer line of defence.‡

An arsenal should be placed so that it can with facility draw in the resources of the country in minerals, timber, and the great mass of raw material required for the construction of munitions of war.

Safety and facility for supply and transport are the chief considerations which must decide the position of an arsenal; and whether for

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* Royal Commissioners on National Defence, May, 1860.

† The Carriage Factory in Bengal is, however, at Futtehghur, far up the country.

‡ Metz. War of 1870–71.

offensive or defensive war, it must be protected by such fortifications as shall ensure its defence by a small force against superior numbers, and oblige the latter to undertake its siege or investment with every probability of final failure.

Provided these conditions are fulfilled, at or near the centre of a manufacturing population would be found the most suitable position for the establishment of an arsenal; for in a position of this kind we might expect to find men, machinery, and *matériel,* which could, in a great emergency, be diverted from their ordinary business and applied to the production of warlike stores, supplementing and expanding the smaller organisation of peace time.

In foreign states we look for large arsenals at the great pivots and bases of offensive and defensive operations, guarded by fortresses* which have grown up with the necessity for the supply and renewment of manœuvring armies.

In our insular position, however, the necessities of our navy, the defence of our harbours and dockyards, have naturally obtained the first rank in importance, while our arsenal and factories have grown into great establishments under the combined action of the requirements of the navy, of our possessions abroad, and the convenience of water transport.

But this convenience is coupled with danger. The concentration of the whole of our constructive establishments upon our outer line of defence is a great evil, and the causes of which we may look for, beyond those I have mentioned before, in the necessity for economy as well as in a disbelief of the possibility of invasion.

In the admirable plan of organisation lately presented to the country —perhaps the greatest step towards the insurance of our independence which has ever been made—we have advanced a considerable way, by the policy of decentralisation of stores.

It is perhaps too much to expect that, following close upon the costly measure of reform about to be commenced, we should suddenly begin to establish one or more arsenals in the central part of the kingdom. It will, however, ultimately be necessary, and let us hope at no very distant period, to complete the comprehensive scheme brought in by the present War Minister, by the establishment of one or more arsenals for the manufacture of the simpler kinds of ammunition, &c., and for the storage of other munitions of war, which shall secure our defensive army the proper supply of these under all circumstances of difficulty.

I am unwilling to leave this important part of the subject without quoting the words of Sidney Herbert, who, in a letter to Major-General

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* "But these should be something more than fortresses—they should contain sufficient material for a great army in artillery, firearms, provisions of all kinds, workshops, arsenals, hospitals; in fact, collecting all the raw material which naturally flows from the surrounding district into a great city, they should be capable of converting it, by means of a large population of artisans and of extensive manufactories, into the material of war—of turning brass into cannon, iron into projectiles and rifles, wood into trains of wagons, wheat into biscuit, canvas into tents, &c."—Hamley's Operations of War, 2nd Ed. p. 307.

Sir Harry Jones, K.C.B., Royal Engineers, Chairman of the Royal Commission on National Defences, dated 25th November, 1859, says:—

"I have the honour to acquaint you that her Majesty's Government have decided it is desirable that the store of guns and warlike *matériel* should no longer be concentrated in one place."

Following upon this came the recommendation of the Royal Commission, in a letter dated May 1860, and their remarks are so important, so closely allied to one of the chief subjects of this essay, and so completely summarise the conditions which should guide the choice of a site for a central arsenal, that I cannot forbear quoting them at length:—

"It appears to us, therefore, that the second arsenal should, as far as possible, be complementary to Woolwich, and should possess those properties in which the latter is deficient.

"To accomplish this, the first requirement seems to be that the new arsenal should be situated nearly in the centre of the country, and as far as possible out of the reach of an enemy making a descent on our shores from any quarter.

"Secondly, it should be situated on the line of retreat that the national army would probably adopt in the event of its being unable to resist the progress of an invader, in order that it might serve as a rallying point, where the resources of the country, both in men and *matériel*, might be collected and organised.

"Thirdly, it is indispensable that it should possess ready means of communication, both by canal and railroad, with the Thames and Severn, the Mersey and Humber, and with the principal seaports of the kingdom.

"Fourthly, it should be situated as nearly as possible to some of the great mineral districts possessing a supply of coal and iron, and in the immediate proximity of a population accustomed to metal working, who might, in an emergency, be employed either in the arsenal, or to supply it with the requisite stores.

"Fifthly, the land on which it is situated should be attainable at a moderate cost, and be of such a nature that a large area may be obtained free from buildings and other obstructions.

"Sixthly, the particular spot chosen should be capable of being defended either by temporary or permanent works, and that at as moderate a cost as possible."*

Defences of the Arsenal.

The manner in which we must endeavour to provide for the security of our arsenal, cannot be treated of with any detail in this essay.

Under ordinary circumstances, we should probably employ a chain of detached forts of a permanent nature, to be supplemented in time of

* The Commission recommended Cannock Chase, in the middle of Staffordshire, and further suggested the establishment of a western arsenal at Runcorn, near Birkenhead.

need by additional earthworks, so as to form the cordon of an entrenched camp which the enemy could not pass by day, and we should construct an inner line to prevent the enemy penetrating by night. The two main conditions to be fulfilled would be—

(1) The safety of the arsenal against a siege or a *coup-de-main*, and with the minimum of garrison.

(2) Space for an army under cover of the works, and freedom for all arms.

The circumstances of each case must, however, vary so much, that it would be useless to attempt to decide on the necessary points for consideration—viz., the strength; the distance of the detached forts from the vital point to be defended; the distance of the enceinte from the vital point, and from the detached forts; the trace of the enceinte, profile; trace, profile and details of the forts; and these matters must be left to the requirements of each case and the skill of the engineer.

4. The General Principles of the Organisation of an Arsenal.

The first great principle is simplicity of arrangement.

Coequal with this, is the opposition to that over-centralisation which burdens one functionary with details which by excessive labour he cannot properly supervise in time of peace, and which must be totally neglected in time of war.

Upon these two principles hang all the rest. Economy of labour, material, and supervision; despatch of business; care of stock; excellence of manufacture; depend upon the above considerations—if by economy we mean the saving of unnecessary expenditure, and not the mere arbitrary retrenchment of expenses which must be incurred sooner or later; if by despatch of business we mean that intelligent routine which must ever be the guide for the efficient performance of numerous duties, but which in time of pressure is able to appreciate the most urgent wants of the service; if by care of stock we mean the care of it by a proper and economical subdivision of labour; and lastly, if by excellence of construction we mean the happy union of efficiency and economy —two terms often separated widely, sometimes utterly divorced, and both susceptible of wide differences of opinion as to their true meaning.

Nothing can be more appropriate to this section of the subject than to present a summary of the fundamental principles of administration enumerated in that remarkable work, "Responsibility in War," by the Archduke Albrecht of Austria:—

1st. To separate and define with precision the circle of action of each one in his own sphere.

2nd. To prevent a superior from encroaching on the circle of action of a subordinate.

3rd. To have as few agents as possible, but those tried men, well paid, and trusted thoroughly.

4th. To prevent the work of superior and central authority degenerating into a purely mechanical routine.

5th. To punish severely any subordinate guilty of arbitrary conduct.

6th. To return without reply, and each time with a reprimand, every useless question which it is the delight of timid and idle officials to send.

In the ideal arsenal whose establishment and organisation I shall endeavour to describe, I shall assume that the arsenal is under the general authority of the Surveyor-General of the Ordnance; that it is under the direct government of a practical artillery officer of administrative ability, acquainted with stores and their manufacture; and that the subordinates are chosen from those branches of the service which can supply capable men, having a knowledge of the class of stores with which they are called upon to deal.

I think few will be inclined to dispute the assertion that the manufacture and supply of warlike stores require special training; and that in addition to the knowledge required of stores in their *passive* state, the officer charged with supply should have a practical knowledge of the *use* of the same. Without this, while it is possible that a department may supply stores with regularity in time of peace, it will probably fail in time of war or emergency, because it will not know what stores should take precedence in manufacture or despatch, nor what may be supplied in lieu of those of another kind when the stock of the stores required is exhausted.

But it may be asserted that it is impossible to obtain a man practically acquainted with, and competent to deal with, all natures of stores. This is perfectly true; but an artillery officer who knows his profession and the requirements of the other branches of the service, who has passed through the manufacturing courses, will probably be found to best fulfil all the necessities of the case, provided he is assisted by men capable of dealing with the work to be done in a practical fashion.*

5. The Details of the Organisation of an Arsenal, divided under three heads, viz:—

A. Storekeeping.
B. Construction.
C. Administration.

Under the head *A* are embraced the various stores and magazines for equipment and *matériel* of all kinds necessary for the supply of an army —the departments charged with the issue and receipt of stores, &c.

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* Upon this portion of the subject the recommendations of the two committees known respectively as Lord Strathnairn's Committee on Supply and Transport, 1867, and Lord Northbrook's Committee on the Conduct of Business in the Army Departments, 1870, bear very strongly.

The opinion of the former was, as is well known, in favour of a distinct Ordnance Department, and was as follows:—"That the custody and management of arms and munitions of war is so special a duty that it could not be conveniently connected with that of other supplies, but that it should be a distinct branch in close connection with the Royal Artillery, who are trained and professionally qualified for such duties."

Lord Northbrook's Committee, however, considered that this would destroy "unity of administra-

Under the head *B*, the various factories or workshops, laboratory, &c.

Under the head *C*, we may class the office portion of the establishment, through whose labours simple accounts and returns of stores, &c., are transmitted to the chief administrative and financial authorities, and the higher *personnel* of the arsenal. It will now be necessary to separate and define the subdivisions of work, enumerating these, the duties and responsibilities of the subordinate *employés*, and showing the manner in which stores should be received and issued.

A. Storekeeping.

For convenience, it may be as well to name the different ranks of officials considered necessary to conduct the business of an arsenal.

The "Head of the Arsenal" may be styled *Superintendent*.

He should be assisted by specially qualified artillery officers as *Assistant-Superintendents*.

The third rank should consist of men chosen from the non-commissioned grades of the artillery, or other branches of the service, or in the case of the factories from civil life, as *Depy.-Asst.-Superintendents*.

The fourth rank may be chosen as the third rank, and would perform the duties of *Storeholders*, &c., with the rank of first-class staff serjeants.

The departments and stores may be as follow :—

1. Department of Issue.
2. " Receipt.

(To these two departments would be attached the Packing Store.)

3. Pattern Room.
4. Armoury Department.
5. Ordnance or Park, including carriages.
6. (*a*) Harness, Saddlery, Horse Appointments; (*b*) Accoutrements.
7. Camp Equipment.
8. Tools and Instruments—*i.e.*, those not kept in set or in regulated equipments.
9. Engineer Store, for distinct use of R.E.
10. Magazines.
11. Raw Material Store.
12. Timber Yard.
13. Breaking-up Store.
14. Unserviceable Store.

1. *Department of Issue.*—This department should be situated close to the entrance of the establishment, with capacious rooms, and large fenced enclosures and sheds attached.

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tion," and recommended that the Control Department should consist of two main sections in the War Office and in the field:—"One for providing and issuing articles required for the daily consumption of an army—such as food, forage, fuel, and light, and for the administration of transport; and the other for receiving and issuing all other stores. The latter division should be placed under an officer who has a professional acquaintance with munitions of war. . . . The education and training which an artillery officer receives is precisely that required for an officer of this division of the Control Department."

The enclosure must be well drained; and both indoors and outside the proper means for accurate weighment must exist, together with appliances such as cranes, &c., for hoisting heavy goods.

This department may conveniently be situated on the left of the general plan of buildings, looking to the front, and the Department of Receipt on the right, which arrangement will greatly facilitate the modes of egress and ingress.

In the organisation of our arsenal, we are not concerned with the method of business by which authority is primarily given for the supply of stores. The requisition may be made to meet a demand for regulated equipment, or to meet an extraordinary demand; and upon the requisition we are required to supply, by issue from store or manufacture, as quickly and efficiently as possible, the articles therein demanded. Instances, however, must occur, when a requisition must be met without the previous approval of superior authority. The responsibility for supply rests, in this case, with the Superintendent of the Arsenal; and it is to this authority alone, or to the Asst.-Superintendent, to whom the duty may be confided, the D.-A.-S. of the Issue Department has to look.

The method of business would be somewhat as follows:—

Requisitions and demands in the prescribed form, after registry and numbering, &c., would pass from the hands of the Superintendent or Asst.-Superintendent to the D.-A.-S. of the Issue Department, who, assisted if necessary, would enter the requisition in his *Requisition Book.*

The requisition should have attached to it a printed form with the names of the various departments of the arsenal and stores, with two columns for date and hour of receipt by the Storeholder. The requisition would then be passed to the latter functionary, who would either copy, or eliminate from the demand, the stores which come under his section, entering them in a book. The requisition would then be passed to the next Storeholder concerned, and so on. The Storeholders interested would have been named or marked off in the first instance on the printed form by the Asst.-Superintendent.

When a Storeholder has not stores to meet the demand, he would at once send in to the Asst.-Superintendent in charge of these departments a Deficiency Report, showing what stores he is unable to supply; these reports would be entered in a guard book for portability, and the Superintendent or Asst.-Superintendent would order the supply, where possible, by manufacture. And here it may be noticed that the Superintendent of an arsenal should always be in a position to execute an order *the authority for which has been given by regulation or by superior power.* The Superintendent, then, is the person who must decide the best manner, whether by manufacture or local contract, in which the demand can be satisfied. On the requisition which comes from superior authority must be shown whether unconditional supply is meant, or whether the condition is named as to the stores being in stock.

The mode of executing, &c., the orders for manufacture will be spoken of hereafter, under section *B.*

The stores for issue would then be brought as soon as possible to the

Department of Issue. The Storeholders would be responsible that the stores were fit for issue. Some of these would be counted, where necessary, examined, and before packing the whole inspected by the Asst.-Superintendent in charge of this department. This officer would be responsible generally for quantity, quality, and pattern. At the same time, it is necessary to observe that this rule, like all others, must admit of modifications. He would be, as it were, the court of appeal of the subordinate officials, who should, however, be held strictly responsible provided they made no reference to him. Upon the nature or usefulness of this reference he would be the deciding authority.

The grand rule is *to procure efficient subordinates, and to trust them.* It is useless to devise a machinery of checks, through which it requires only a little cunning to break, and which in time of pressure necessarily falls to pieces.

The *Packing Store* should be close at hand, so that the boxes and cases required, with other materials, might be available for ready packing in the Department of Issue. The non-commissioned officer in charge would be under the orders of the D.-A.-S. of Issue. All materials and tools would be drawn in the usual way from the stores, and written off "for use;" the tools, however, being accounted for in a general secondary Store Ledger of the arsenal, containing those tools "for use," and thus separating these from the available or reserve stores.

The rules regarding packing must be founded on the nature of stores, climate, means of transit, and common sense.

The packages for despatch—classes of articles being kept separate where possible—should be marked according to those regulations which govern the marking of stores for an army in the field, the weight of the package marked, and where possible a rough list of contents. Such a system entails but little labour at the outset, and may save an immense deal to those charged with the receipt of stores.

In urgent cases, the Asst.-Superintendent should take upon himself to personally direct a necessary issue of stores; the requisition being first entered by the Storeholder supplying, and then handed over to the D.-A.-S. of the Issue Department.

The invoices should be made out by the D.-A.-S. of Issue, one copy being enclosed with the stores, the other sent to the office for transmission to the corps or department to which the stores are despatched.

As "unserviceable" stores may sometimes be ordered to be sold or broken up, the Requisition Book of the Issue Department should possess columns showing the nature of stores, whether "serviceable" or "unserviceable," and whether they have been issued for army use, or merely on "sale," or for "breaking up."

The duties of the D.-A.-S. of this department are numerous, responsible, and require a man of experience, intelligence, and method, and well acquainted with military stores.

The transit of stores to the means of conveyance—whether rail, water, or road—would be conducted by an assistant, subordinate to the D.-A.-S. in charge of the Issue Department.

There are many minor details of routine—such as the requisition being numbered by the *passing* authority, and also by the arsenal, &c., &c., but these cannot be treated of here.

2. *Department of Receipt.*—The storerooms of this department must be adjacent to those for issue, but so separated as to prevent liability to the mixture of stores coming in and going out.

Stores received may be classed as follows:—

(*a*) "Unserviceable" or obsolete stores, returned from regiments, batteries, or departments.
(*b*) "serviceable," returned owing to departure of regiment, &c., or change.
(*c*) Stores from factories of arsenal, or other Government factories.
(*d*) Stores from contractors, to replace or complete stock.

(*a*) The regulations on this head are generally understood, and need not here be repeated. Personal communication between the officer sending in the stores and the Asst.-Superintendent will often adjust matters of difference. The tendency to call for special Boards of Survey should be checked, as the officer returning the stores and the officials of the arsenal should be mutually responsible for the correct performance of duty. It is needless to point out, what is a matter of regulation—that no stores can be condemned for mere change in pattern. No state in the world could bear the expense of continual replacement, and it should be the duty of all officers to use stores committed to their charge as their own property, and not regard the supplying department as a mere agent for drawing upon an inexhaustible source of wealth;* while on the other hand, those departmental officers charged with supply should know the requirements of the service, and the uses of the articles they issue, so as to be able to supervise them efficiently, and have a fair judgment on those returned for receipt.

(*b*) Care is of course necessary that the stores of this class answer in quality and quantity to their invoices.

(*c*) Same remark is applicable.

(*d*) Stores of this class require especial attention.

In the receipt of combustible stores great care is necessary, and they must be examined in some safe place, under the special supervision of the D.-A.-S. in charge of the magazines, who would, when necessary, call in the assistance of the Laboratory.

In this department, the D.-A.-S. in charge, or his assistant, will personally superintend the unloading and opening of all packages.

The stores will then be counted, &c., and their condition, after their entry in the Receipt Book, carefully inspected and shown; the invoice being marked "correct" or otherwise, so that the Asst.-Superintendent in charge may know what course to adopt. The stores will then be received over by the various Storeholders, and the invoice will be forwarded to the Asst.-Superintendent for registry in the office, and com-

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* A really important point is correctness of "nomenclature;" only those charged with supply of stores can appreciate the difficulties of supply when this is wanting. Full information, and drawings with specifications should be given when the article demanded is a new supply. This prevents much labour in reference.

parison with the entry in the Store Ledger, which will be made from the books of the various Storeholders. The D.-A.-S. of this department is the natural custodian of all invoices received, until the stores are handed over to the Storeholders. The Storeholder receiving stores must be responsible for their proper entry in his books.

The condition of the stores would ordinarily be ascertained on receipt by the Asst.-Superintendent, assisted by the D.-A.-S. of Receipt Department, and he would decide in the case of "unserviceable" or "repairable" stores the course that should be followed; but in all cases the stores must be shown on the Store Ledger as "received."

3. *Pattern Room.*—Should be in close proximity to the Issue and Receipt Departments. The patterns should be arranged according to the departments of the arsenal, so that each Storeholder should know where to look at once for any pattern. An accurate catalogue should be kept, and all drawings carefully arranged.

Attached to the Pattern Room should be a small library, containing works treating of technical military matters. The officer in charge must make himself acquainted with all new stores.

4. *Armoury Department.*—This department, containing all small-arms and materials for their repair, would be an extensive but simple charge. The same kind of arms should only be kept in one rack and properly labelled.

In a second-class arsenal, and where a small-arms factory is not included, it will be well to have the small-arms workshops near the armoury, so that the functionary in charge, who should have been well trained in the small-arms factory, could efficiently supervise the workshops, which would, however, be under the general superintendence of the officer in charge of the other arsenal workshops.

5. *Ordnance or Park Department.*—Under this head we may group :—

(*a*) Ordnance, carriages, projectiles, and stores* for garrison service.
(*b*) Ordnance, carriages, projectiles, and stores* for field service; including materials for repairs supplied to batteries.
(*c*) Ordnance, carriages, projectiles, and stores* for siege service.

In this department we may note the necessity for intelligent classification, for accurate tables of equipment and proportions, and that the D.-A.-S. in charge, or Storeholder, should be a practical artilleryman. For this department large and well drained spaces, with good sheds, must be appropriated.

6. *Harness, &c., Store,* including materials for repair of the same. The Storeholder would be selected from the cavalry, or mounted branch of the artillery.

7. *Camp Equipment.*

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* Not ammunition.

8. *Tools and Instruments.*—This department might be in charge of a man whose turn of mind was mechanical. It would contain all tools not kept with special equipments. It would sometimes be found advantageous to add this charge to,

9. *Engineer Store,* including engineer equipments, such as pontoons, &c., not common to the other branches of the service. The Storeholder should be selected from the R.E.

10. *Magazines.*—The magazines, although forming an integral part of the administration of an arsenal, would be placed in positions of safety, consistent with facility of supply. The chief points to be attended to are :—

(1) Precautions for safety.
(2) Freedom from damp.
(3) Ventilation.

The regulations for the safety of magazines do not need repetition here, as every officer is expected to know them as contained in the Queen's Regulations.

The separation of combustible stores is an important point—*i.e.*, the division of powder, which should be kept by itself, from other stores; tubes, fuzes, cartridges (empty and filled), &c., being kept in a separate magazine. In all magazines very clear arrangement is necessary, and a list of the stores contained should always be placed on the exterior door, the quantities being inserted in a column which may be renewed from time to time by pasting over strips of paper. All cases and barrels should be legibly labelled.

In the present day, a very strong construction of magazine is required.

Projectiles—*i.e.*, shot and empty shell—have been allotted to No. 5, the Ordnance or Park Department, because it is deemed better to keep these heavy articles near the Issue Department, and divided from the combustible part of ammunition, which must be stored in a place of safety.

11. *Raw Material Store.*—For materials such as iron, copper, brass, zinc, rope, oils, paints, paper, cloths, canvas, &c., &c.—*i.e.*, all those materials that are kept in stock to work up for use.

12. *Timber Yard.*—Under this head are embraced the duties of receiving, examining, and stacking timber. The examination prior to receipt from a contractor would be most properly performed by an officer of the Carriage Department. In a second-class arsenal this duty would be performed by one of the officers of the arsenal, assisted if necessary.

13. *Breaking-up Store.*—Must be located in a safe place, and superintended by a careful man, so that the destruction of damaged or obsolete combustible stores may be attended with as little risk as possible.

14. *Unserviceable Store.*—Requires no special knowledge, and would hold stores condemned for sale or conversion.

Having thus fixed the general division of the stores, it will be necessary to make a few remarks on storehouses, and the duties of those entrusted with their management.

The buildings required for storehouses should be spacious, dry, airy, easily accessible, and connected with the Issue and Receipt Departments by tramways, for conveyance of the more bulky goods. The whole of the buildings must be enclosed, and an adequate military guard must be furnished for their protection and care. Strict precautions must be taken against fire, and the establishment frequently exercised with a view to the ready supply of water.

Storeholders are placed in positions of trust involving :—

(1) Care over every article entrusted to them.
(2) Habits of order, arrangement, and punctuality.
(3) Scrupulous care in seeing that issues and receipts truly correspond to invoices and vouchers in quantity and quality.
(4) Quickness in registry of transactions in their books.
(5) Constant supervision to prevent deterioration, to render "repairable" stores efficient, and to bring forward for condemnation those considered "unserviceable."
(6) Constant stock-taking.

Neatness of arrangement, cleanliness of the store, keeping together classes of articles, a proper system of labelling according to the prescribed nomenclature, care as to dryness and freedom from insects, &c., are all points for particular attention.

The multiplication of books and returns is a great evil, and they should be in printed form, condensed, and as simple as possible. Each Storeholder should have a Division Store Ledger, showing stores classed as "serviceable," "repairable," and "unserviceable;" a Day Book, showing issues, receipts, and temporary loans to other branches of the arsenal; a Requisition Book, showing copies of demands, or extracts therefrom; a book containing copies of orders relating to the particular charge.

In all cases repairs of stores should be executed on the authority of the Storeholder, in the factories or workshops, as the labour will be more satisfactorily applied, and the method of account simplified.

B. Construction.

In a first-class arsenal, the departments for manufacture will consist of:—

1. Gun Factories.
2. Carriage Department.
3. Laboratory.
4. Small-Arms Factory.
5. Harness, &c., Factory.

The powder factory cannot be held to belong to the arsenal, though it should be situated in the zone of defence.

1. *Gun Factories.*—Any attempt to mention the machinery required, to give an account of the process of manufacture for this or that system, would extend this essay to a large volume. Only an officer practically acquainted with gun manufacture should be placed at the head of this establishment, or could hope to organise it properly. In this, as in every other branch, the great point to be attended to is the employment of good men and good machinery, arranging the buildings so that the work in the rough may be gradually elaborated, and passed on in natural order from stage to stage through all its processes.

Opinions concerning the relative merits of one system of gun construction or another can form no part of the present essay, nor would it be practicable to introduce details of manufacture.

The proof of ordnance and of powder seems to be a natural duty of this department, and the Superintendent, therefore, and his subordinates, should be qualified to use the various scientific electro-magnetic apparatus used therein. Projectiles for guns would be made in this department, which would also be required to furnish to the trade drawings and specifications, in order that Government factories might be supplemented by private enterprise in time of emergency.

2. *Carriage Department.*—Under this head it would be necessary to provide for the construction of travelling carriages for field and siege artillery, engineer and army service carriages, gun-carriages for garrison service, travelling platforms, the numerous artillery machines, mortar beds, naval carriages, miscellaneous stores connected with artillery service, woodwork of saddles, and pack-saddle equipment.

3. *Laboratory.*—This department must be prepared to manufacture every kind of ammunition (except projectiles for ordnance)—such as cartridges, fuzes, lubricators, wads, tubes, primers, portfires, mining *matériel*, rockets, &c., &c.*

4. *Small-Arms Factory.*—In addition to working the extensive plant required, this department would be charged with survey of all arms received from the trade, and with the repair of all small-arms.

5. *Harness Factory, &c.*—This should include workshops for the making of accoutrements and tents. The knowledge required for the preparation of leather, &c., is peculiar, and the Superintendents would generally be drawn from civil life.

In a second-class arsenal these large factories would be replaced by workshops, for the performance of minor processes analogous to the larger operations. We should require—

(1) A workshop containing lathes, and all machines for turning, boring, and fitting.

(2) Smiths' shop and forges.

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* One of the great necessities for this department is obviously the reduction of risk to a minimum. An account of the late trials under Capt. Majendie, R.A., with regard to maximum quantity of powder in cartridge filling sheds, distance of sheds, &c., may be found at p. 204, Vol. IX. "Proceedings of Department of Director of Artillery."

(3) (*a*) Carpenters' and wheelers' shops, where carriages might be made and repaired; (*b*) Coopers' shop; (*c*) Painters' shop.
(4) Collar-makers' shop, for repair of harness, tents, &c.
(5) Laboratory, where all the simpler kinds of ammunition could be made up.
(6) Armoury workshops, with all the lathes and tools for the repair of small-arms.

In all workshops there are certain principles which must be observed. These are: economy of material, facility of manufacture, proper application of skilled labour, and quickness in completion of work.

The charge of these workshops is so heavy that in any large arsenal it should be entrusted to an Asst.-Superintendent, well trained in the manufacture of warlike stores, assisted by a D.-A.-Superintendent, who should be a practical mechanic. Each workshop must have at its head a man responsible for discipline and work, and the prevention of idling and wastage. There should be an expense store, where the material to be worked up should be kept and accounted for. In each workshop there must be proper places for tools, to be put away at the conclusion of the day.

The necessary account of material must be simple in form, so that the time of those superintending manufacture may not be taken from the first objects of attention. Stores to be used in construction would be drawn in the usual manner from the storehouses of the arsenal, on the authority of the Asst.-Superintendent. The Day Book would show stores received to complete orders for work on No. — Requisition, and work issued. A daily report of work executed, and workmen and material employed, would form the basis upon which the administrative department would show the cost of manufacture. An Order Book would contain the necessary copies of orders and instructions.

Spaces must be set apart for stores received and for issue to the other branches of the arsenal; and for all constructions the Asst.-Superintendent in charge must be responsible that they are according to the authorised pattern. Stores manufactured must pass through the hands of the proper Storeholder, by whom they would be delivered to the D.-A.-S. of the Issue Department, as this routine is necessary, in order that the former may know of the completion of his portion of the requisition.

The *personnel* of the workshops would consist of Asst.-Superintendent, Dep.-Asst.-Superintendent as foreman, collar-makers, carpenters, coopers, smiths, painters, engineers, armourers, wheelers, laboratory workmen, and labourers.

All labourers might be attached to this portion of the arsenal, and detailed daily for the requirements of any portion of it, so that the work may be executed wholesale, and not dispersed over the whole establishment, when it becomes impossible to supervise it efficiently.

C. Administration.

The duties of Superintendent demand an aptitude for administration and a knowledge of manufacture. An intimate technical knowledge is, however, not so necessary as the power of utilising the knowledge of others in regard to details of manufacture, for the production of the

best stores with the greatest practicable economy and rapidity. Knowledge of manufacture is not so much required in the administrator as a knowledge of *man*. At the same time, great manufacturing knowledge and power of administration are by no means incompatible. The Superintendent, and the officer in charge of the workshops, must ever be considering and taking counsel with their subordinates, regarding improvements which can be effected in manufacture, or in administration. Unless this be done, the whole system sinks into one deep groove, from which in time of emergency it is unable to rise and seize the opportunity presented for the expansion of ideas and the development of work. The Superintendent must be a man of such tact and demeanour, that his moral power and personal influence may be brought to bear on the execution of work. It is his duty to see that everything under his control is in the highest state of efficiency, and that the stores are fit for immediate issue; that the taking of "stock" or "remains" is executed in accordance with the rules of the service, and that this work continually progresses through the departments at regular dates.*

The Superintendent must supervise the preparation of the estimates, and he must be responsible that the regulated proportions of stores are continually kept up, and the sums granted in the estimates expended as they are allotted. The application of the skilled labour at disposal; the apportionment of duties to the *personnel* consistent with the knowledge and power of individuals, or classes of men; these form part of the personal duties of the Superintendent.

By this brief summary it will be seen how varied and important are the duties of this functionary. He must be guided by ordinary rules in time of peace, and yet know how to shake himself free from the restraint of routine when he shall judge that the urgency of the case demands such a responsibility.

The duties of the Asst.-Superintendents must vary with the requirements of the arsenal. Thus, in a second-class arsenal, one might be placed in charge of all the storehouses, a second in charge of the Issue and Receipt Departments, while a third would be placed in charge of the workshops. One of them would be placed in supervision of the "interior economy" of the arsenal. Under him would come supervision of labourers in the arsenal; to him applications for leave, &c., would be made; the keeping of fine books, defaulters' book, nominal roll, &c., being performed under his orders. It might be possible to have only two Asst.-Superintendents, but in an arsenal of any size this would be impracticable.

The Depy.-Asst.-Superintendents and serjeants must be proportioned in number to the necessities of the work. In some cases the stores enumerated might be amalgamated into fewer departments, but retaining the same separation as to classes.

Circumstances must decide the number of *employés*. The wants and capacity of the arsenal can alone determine the *personnel*.

The office establishment of the arsenal should be sufficient for con-

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* In a large arsenal it would be impossible to take stock of the whole of the stock at one particular time in five years, according to rule, as it would render necessary a stoppage of all current work.

ducting the correspondence, collecting the returns of labour and material into such a form that audit may be rendered easy; for compilement of the Store Ledger upon the basis of the Storeholders' books, who should attend at the conclusion of the day's work; and the work will be facilitated by the Store Ledger being divided into books on printed form corresponding to the divisions of the arsenal.

An arsenal should form no department of account. The Store Ledger, an account of material and labour expended, with the necessary account of the wages, &c., of the *employés*, and the expenditure of cash for contingencies, should be all that ought to be demanded from such an establishment.

The Administrative Department is that which should compute the prices of stores, for it alone is in possession of all the information which can form the basis of a proper investigation. The result of any attempt to do this by a lower authority is merely empirical. The Administrative Department is that which should examine store accounts, and exercise such supervision that economy and efficiency are combined, and neither sacrificed to the other; the supreme financial authority controlling the whole, through the agency of the Financial Secretary.

Concluding Remarks.

In treating this large subject, I have desired to deal with it in a practical rather than in a theoretical spirit. I might have glanced at the systems of foreign nations,* but in these matters I do not think we should gain by the imitation of a foreign model. I might have attempted to detail machinery and processes of manufacture, and essayed to describe the grand triumphs of human skill achieved in our factories; or, led away by the charms of the subject in its pictorial aspect, I might have tried to paint in words—

> "The roof ribs swarth, the candent hearth,
> The ruddy, lurid row
> Of smiths, that stand—an ardent band—
> Like men before the foe."

I have, however, preferred to treat the subject in its most prosaic light, and have been guided by a consideration of what is most probable rather than of what is only remotely possible.

I cannot but feel how imperfectly I have treated a subject which is full of interest to artillery officers, and to those of other branches of the service who desire to rise above the immediate routine of military life. I am consoled by the reflection that no effort, however humble, can be contemned by soldiers who are seeking to perfect themselves in every branch of the art of war. We cannot all be great generals, or great administrators, but we can all try to develop our powers to the utmost, so that we may make the highest use of our respective talents, to the safety and honour of our country.

March 14, 1872.

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* Those who are interested in the matter will find a complete account of the French system in Vol. 1, "Cour d'Administration Militaire," by Vauchelle; and of the Prussian system some account is given in "Die Verwaltung des Norddeutschen Bundesheeres," by A. Froelich, of the Prussian Intendantur.

SKETCHES

OF

ARTILLERY AND INFANTRY ATTACK AND DEFENCE,

(AFTER THE GERMAN),

AND A

NOTE ON INFANTRY COLUMN AND LINE.

BY

LIEUT.-COLONEL W. J. WILLIAMS, R.A.

HOWEVER much manœuvres in battle may be adapted to the cover on the ground, and however freely and loosely a highly trained and intelligent soldiery may be allowed to fight, it is yet necessary to practice in peace, in order to have to work upon, according to circumstances in war, the best arrangement of the three arms—of each with regard to the other two, and of each in itself.

ATTACK.

I.

Infantry in skirmishing order to advance and take up a line 1500 yds. from the enemy.

This line would be 500 yds. in front of our line if we were in order of battle, and 1000 yds. from the heads of our columns should we not be formed up.

This advance may be general along the front, or only partial.

The extended line need not be strongly supported: it is not a fighting line for infantry.

II.

Artillery to advance and come into action in the extended line of infantry.

Batteries should be placed together in line. The infantry should leave the guns clear, and extend on the flanks.

The distance of 1500 yds. from the first line of the enemy is the best distance for the first position of artillery. The guns would hold the first line of the enemy fairly within range. It is not a very dangerous distance, even for artillery unsupported; there would not be too great sacrifice at the very beginning of the fight. It is a convenient distance with regard to the next advance of artillery, when the guns must be placed within a more decisive range, and in a position to fire as long as possible across the front of the attack.

III.

The extended line of infantry, supported by more infantry from the rear, to move forward from both flanks and gain new positions for artillery 500 yds. in advance—1000 yds. from the first line of the enemy.

The infantry in their advance must be careful not to mask the artillery in the centre.

IV.

The infantry from the rear intended for the assault, to commence their advance in two lines 300 yds. apart.

If more than one brigade is sent, brigades should be side by side rather than one in rear of another.

V.

Artillery from the rear to advance on both flanks, to pass the artillery remaining in action in the centre, and to gallop up into action on the flanks at 1000 yds. from the enemy.

These positions on the flanks should be taken up so far apart as to leave space for the infantry advance in the centre, and to allow of the fire being directed inwards upon the enemy for some time after the infantry have passed the level of the guns.

If these positions should be in front of the flanks of a small force, they would be defended on the outside by the advanced infantry, strongly supported, and their safety would further be watched for by cavalry; on their inner flanks they would be defended by the artillery still in action in the centre, and by the advancing infantry attack. In a great battle, advanced artillery positions would be defended on their outer flanks by artillery echeloned to the rear.

To give proper support to an infantry attack, it would almost always be necessary to place artillery within 1000 yds. of the enemy. The guns must hold all the first line of the enemy, skirmishers, supports, and reserve, and whatever may come up to support the first line, within close range; and the guns must be so far advanced as to be able to direct their fire across the front of the attack until the skirmishers of the attack are within close range of the skirmishers of the enemy.

VI.

The infantry, in two lines 300 yds. apart, to pass through the artillery, firing until the last moment in the centre.

It is better for the infantry to pass through these guns than for the guns to be moved before the passage of the infantry. The infantry, in marching on and through the guns, would incur no danger that they would not otherwise incur in advancing; they would march through in lines, only breaking off files; there would be no delay for the infantry. The artillery would fire longer, and the last minutes of this direct fire upon that part of the line of the enemy which is to be assailed are of importance.

VII.

When the second line of infantry has passed, the artillery in the centre to wheel outwards and gallop up to reinforce the artillery on the flanks.

All the guns thus placed on the flanks continue to fire until the attack has been brought to an issue.

The advance of the artillery from the centre to reinforce the artillery on the flanks would in most cases be the last move in the artillery attack; for the guns being within 1000 yds. of the enemy, it would seldom be worth while to take up new positions to lessen the range.

VIII.

The infantry, in two lines 300 yds. apart, to continue to advance, under cover of the fire of the artillery on both flanks, until the first line of infantry comes within range of the skirmishers of the enemy—800 yds. At 800 yds. from the enemy, the infantry to take order for the attack.

The first line breaks up, by battalions, into skirmishers, supports, and reserve, with distances of 150 yds.; each battalion taking a front equal to the length of a battalion deployed. The second line remains in line at 300 yds. in rear of the reserves of the first line. The skirmishers are thus at 500 yds. from the enemy, and the second line at 1100 yds.

Now, and during all the advance, the infantry, when not actually moving forward, lie down.

IX.

As soon as possible after the attack is formed, the skirmishers to advance to within 300 yds. of the enemy, there to lie down and fire, to cover the advance of the rear formations.

All the advances are made suddenly, by gaining short distances at a run.

In the advance of the rear formations, all the distances are lessened. The second line must gain more rapidly on the reserves of the first line than the reserves on the supports, or the supports on the skirmishers.

X.

The skirmishers to run forward and take up nearer and nearer positions in which to lie down and fire. The supports and reserve constantly

to reinforce the skirmishers, and to close upon them as they approach the enemy. The second line constantly to close upon the first line. When the second line is within 50 yds. of the first line, the whole to charge.

Defence.

I.

In order of battle for the defence, infantry and artillery are ranged in first line, second line, and third line, or reserve.

To facilitate command, brigades should be placed side by side, rather than one in rear of another.

II.

In the first line, the infantry are in skirmishing order, with supports and reserves at distances of 150 yds., each battalion holding a front equal to the front of a battalion deployed. The artillery are in line with the skirmishers.

Having regard to the fighting of the first line with the enemy within close musketry range, and to the fact that 100 yds. of continuous close musketry fire in defence is better even than the fire of a battery firing case—if it were only because the infantry can be reinforced—battery should be separated from battery in line by intervals of at least two battalions. Viewing, on the other hand, the necessity of combating the artillery of the attack, the proportion of artillery in first line should be as large as it may be.

III.

The second line of infantry is deployed at 300 yds. distance from the reserves of the first line, or at 600 yds. from the front. The third line is deployed at 300 yds. from the second line.

The divisional artillery not in first line is with the second line. The artillery of the reserve is brigaded together in whole or in parts.

IV.

The line of skirmishers and guns is the line to be everywhere defended.

The fighting of the infantry in the defence is governed by these principles:—Very few infantry should be at first placed in the line of skirmishers, that unnecessary loss should not be suffered from the artillery fire of the enemy; the line of skirmishers should be constantly strengthened in the face of an attack, so that all the infantry of the first line, and even reinforcements from the second line, may take part in the fire fight, and what was at first a thin line of skirmishers shall become at last a closed line, before the enemy charges; the second line

and third line should advance to distances of 50 yds. to sustain the first line at the crisis.

One line should never relieve another line in battle, nor should skirmishers ever be brought back; but what is in rear should be advanced to reinforce what is in front.

V.

The artillery fight thus:—The guns of the first line open fire upon the enemy when he comes within effective range—2000 yds. The guns of the second line reinforce the guns of the first line, to fire upon the artillery of the enemy advanced on the flanks of his attack. Guns must not be advanced in the face of an infantry attack of the enemy so as to mask the infantry of the defence.

The guns in first line must remain in action until the very last.

NOTE ON LINE AND COLUMN OF INFANTRY.

Line is always necessary in front, for the greater development of musketry fire; and line is the safer formation under artillery fire. Column is a safer formation under musketry fire for all troops not actually in front; and we must have columns to oppose columns, when the columns of the enemy, being screened, are not exposed to the concentrated fire of our line.

Our battalion columns collect too many men in one place. We object to form our second line into battalion columns for close battle, not because that formation would be more dangerous—for it would really be less dangerous—but because it is according to our old traditions to fight in line. If, however, it were ordered that the second line should form battalion columns when within 500 yds. of the enemy, the battalion columns would not in close battle properly support the battalions in line; the columns would actually support the line only at intervals too far between; and, moreover, the columns would be wastefully strong.

By regulation and tradition, we are to go into battle in two lines. We should certainly have to fight against some order of line and column combined. If we should to the last preserve any considerable distance between our lines, they might be beaten in detail; if we should at the last close our second line upon our first line, both might be overwhelmed in the same disaster. In either case there would be no reserve; the troops would get out of hand whole lines at a time. However, we should most likely win, because we always have won; but we should win only by the men breaking the order in which they were led into action, and falling instinctively into that order which is denied them by regulation—that is to say, by the second line closing upon the first, and the men swarming at intervals along the line.

If our battalions were divided into eight companies, and drilled to manœuvre in four columns—each of two companies in column of half companies—and also in two columns—each of four companies in column of companies—we should have the Prussian company columns and half battalions. We should have columns to support lines in close battle, and we should get rid of the evil of having a second deployed line, weak to support a charge, and unable to fire, but receiving all the fire passing through the deployment in front.

Even with the present organisation of ten companies to a battalion, it would be well to drill to manœuvre in five columns of four half-companies each.

SHORNCLIFFE,

April 23, 1872.

PRÉCIS OF REPORT

OF

COLONEL BARON HENRI BERGE,

OF THE FRENCH ARTILLERY,

UPON

THE BRITISH 9-PR. M.L. GUN.

BY

LIEUT.-COLONEL W. E. M. REILLY, C.B., R.A.

Baron Henri Berge, Colonel of the French artillery, was deputed by his Government during the summer of 1871 to visit England and Belgium, and study the systems of field artillery adopted by those countries, as representing in the greatest perfection the rival systems of M.L. and B.L. guns. Baron Berge has made a report to the French Minister of War, a *précis* of which will be found of interest.

Colonel Berge commences his report by drawing attention to the fact that so far back as 1833 the use of iron for artillery carriages was recommended by General Thiéry to Marshal Soult, then Minister of War. General Thiéry observes that wood and soft metals were then, as in the infancy of mechanical art, the only materials in use in the artillery. With such perishable materials peace is almost as ruinous as war; and as a proof of this, it was only necessary to quote the large sums of money expended in the arsenals for repair of carriages during the fifteen years of peace up to 1830. He strongly advocates the adoption of iron. It would appear, however, that General Thiéry's opinions were in advance of his time, for a report inserted in the "Mémorial de l'Artillerie," No. 4, of 1837, thus concludes:—"The results have produced a unanimous opinion that *matériel* of iron is inapplicable to the defence of fortresses and coasts." And so the question dropped.

At the present moment, says Colonel Berge, it is no longer necessary to discuss the advantages claimed for iron carriages by General Thiéry. Since that day all has been changed in Europe. All the changes which have been effected render mobilisation more rapid, armaments more sudden, the attack more bold, the defence more perilous. All nations are held in readiness to fight. To be before your adversary a few days —a few hours—is already to have gained guarantees of victory. The most common prudence demands, therefore, to reject all arrangements which could cause delay. One of the practices which it is most essential to abandon is the storing of the carriages for field service in the arsenals. There should be about 20,000 of these carriages for the artillery alone. It is a folly to continue to pack them in piles which cannot be taken down without the assistance of a great number of workmen and a month's delay. On the contrary, it is absolutely necessary that the batteries should always have their *matériel* complete and ready for service, at

their own disposition, and at hand. Henceforward all the carriages, including those for the parks, should be kept mounted, completely equipped, and ready to move. The consequence of this political necessity is the construction of carriages of iron, which can be exposed to the air without decaying, and which a touch of paint annually suffices to preserve.

Colonel Berge gives a detailed description of the mode of manufacture employed in constructing these carriages in the Arsenal at Woolwich, which he highly praises. He approves of the packing of the ammunition and the equipment of the wagons, everything that is requisite being carried by the battery, and everything in a convenient and proper place—a marked contrast to the arrangements of a French battery, the captain of which is not allowed the use of a nail or a piece of string, and then astonishment is expressed if on the march the road is strewn with sacks and corn.

Colonel Berge finds that the English *matériel* has faults which his Government should endeavour to avoid. The solidity of workmanship is unnecessary. For the same total weight he thinks it would be better to make the piece heavier and the carriage lighter. The rivets are too many, and the carriage should be made in fewer pieces. The extreme angle of elevation should be greater, and should be obtained without burying the trail in the ground. The sighting appears too complicated; several alterations could be suggested. The employment of the means of giving the piece a lateral movement is indispensable for long ranges. The Armstrong gun had such an arrangement; no good reason appears to exist why a similar arrangement was not adopted for the new gun. Colonel Berge, in closing this portion of his remarks, repeats that the employment of iron largely in carriage manufacture is of the greatest advantage, and he adds:—We shall incur a heavy responsibility if we do not appreciate this new progress in the military industrial art, for it is still more indispensable to France than any other power to adopt the principle.

The report gives a detailed description of the new gun, which is a simple modification of the French gun, but the modifications have been completely successful in obtaining the accuracy which the French gun wanted.

It then proceeds:—This transformation is nearly completed. The English Minister continues to approve of it, but he declares at the same time that if in a few years he finds something better, he will not hesitate for a moment to sacrifice the work which he has just completed.

To better understand the advantages and defects of the system, Colonel Berge compares it with what he says was up to this moment considered the best gun in Europe—the Belgian gun.

The examination is divided as follows:—

1. The initial velocity.
2. The trajectory.
3. The extreme range.
4. Accuracy.
5. Effect of the projectiles.
6. System of loading.
7. Rapidity of fire.
8. Mobility.

Of all the field guns in Europe, the English 9-pr. M.L. has the highest initial velocity:—

		m.
1. English 9-pr., charge $\frac{1}{5}$	....	420
2. Belgian........... " ... $\frac{1}{8}$	....	372
3. Prussian .... " ... $\frac{1}{8}$	....	360
4. Austrian .... " ... $\frac{1}{7}$	....	335
5. French .... " ... $\frac{1}{7}$	....	325
6. Russian .... " ... $\frac{1}{8}$	....	305

The gun which approaches the nearest to the English gun is the French gun of 7 ins., with a velocity of 400 mètres.

The following table shows the elevation of the French, English, Belgian, and Prussian guns at different ranges:—

TABLEAU No. 4.

Tableau des angles de tir.

Distances.	Anglais, Maxwell, 16 livres, No. 1.	Français, 7 kilog., No. 2.	Anglais, Maxwell, 9 livres, No. 3.	Belge, 6, No. 4.	Prussien, 6, No. 5.	Belge, 4, No. 6.	Prussien, 4, No. 7.	Anglais, Armstrong, 9 livres, No. 8.	Français, 4, No. 9.	Français, 12, No. 12.
mètres	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′
500	—	—	—	1 12	1 21	0 54	1 8	—	—	—
600	—	—	—	1 24	—	1 6	—	1 5	1 30	1 40
700	1 5	—	—	1 42	—	1 24	—	—	—	—
800	1 20	1 25	1 28	2 0	—	1 36	—	—	2 10	2 30
900	1 36	—	—	2 18	—	1 54	—	—	—	—
1000	1 52	1 57	1 57	2 36	2 53	2 12	2 20	2 55	2 50	3 20
1100	2 8	—	—	2 54	—	2 30	—	3 10	3 15	3 50
1200	2 24	2 32	2 31	3 12	—	2 48	—	—	3 40	4 25
1300	2 40	—	—	3 30	—	3 6	—	—	—	—
1400	2 57	—	—	3 48	—	3 24	—	—	—	—
1500	3 14	3 29	3 29	4 12	4 38	3 42	—	—	5 5	6 0
1600	3 32	—	—	4 30	4 50	4 6	4 4	5 4	5 35	6 35
1700	3 50	—	—	4 48	—	4 24	—	—	—	—
1800	4 10	4 30	4 35	5 12	—	4 48	5 10	—	—	—
1900	4 30	—	—	5 36	—	5 2	—	—	—	—
2000	4 50	5 33	5 47	5 54	6 30	5 30	5 56	7 40	7 45	9 0
2100	5 10	—	—	6 18	—	5 54	—	—	—	—
2200	5 34	—	—	6 42	—	6 18	—	—	—	—
2300	5 52	—	—	7 6	—	6 48	—	—	—	—
2400	6 18	—	—	7 30	—	7 12	—	—	—	—
2500	6 40	7 9	7 38	7 54	8 38	7 30	8 8	—	11 0	12 20
2600	7 4	—	—	8 24	—	8 6	—	—	—	—
2700	7 26	—	—	8 48	—	8 36	—	—	—	—
2800	7 50	—	9 18	9 18	—	9 6	—	—	13 25	14 35
2900	8 17	—	—	9 48	—	9 36	—	—	—	—
3000	8 39	9 21	10 21	10 18	10 45	10 1	10 34	—	15 10	16 0
3100	9 1	—	—	10 48	—	10 36	—	—	—	—
3200	9 23	—	—	11 18	—	10 6	—	—	—	—
3300	9 46	—	—	11 48	—	10 42	—	—	—	—
3400	10 15	11 18	12 35	12 18	—	12 12	—	—	—	—
3500	—	—	—	12 54	—	12 48	—	—	—	—
3600	—	—	—	—	—	—	—	—	—	—
3700	—	—	—	—	15 23	—	14 45	—	—	—
4000	—	—	—	15 54	—	15 54	—	—	—	—

The flatness of the trajectory is in favour of the English gun over all other field guns; the Belgian approaches nearest to it. The construction of the English shell is such as to unite all the conditions which are requisite to obtain a great range. At 20°—the highest angle the carriage allows of—a range is obtained of 5000 mètres.

TABLEAU No. 5.

Tableau des écarts moyens rapportés au point moyen.

Distances.	Français.				Anglais.				Belges.				Prussien.	
	12 rayé. Écarts.		4 rayé. Écarts.		Armstrong, 9 livres. Écarts.		Maxwell, 9 livres. Écarts.		6 rayé. Écarts.		4 rayé. Écarts.		4 rayé. Écarts.	
	Hauteur.	Direction	Hauteur.	Direction	Hauteur.	Direction	Hauteur.	Direction	Hauteur.	Direction	Hauteur.	Direction	Hauteur.	Direction
mètres.	m. c.	m. c.	m. c.	m. c.	m. c.	m. c.	m. c.	m. c.	m. c.	m. c.	m. c.	m. c.	m. c.	m. c.
1000	0 75	1 47	1 45	1 20	—	—	—	—	0 56	0 70	0 65	0 75	0 65	0 50
1200	—	—	2 0	1 40	1 50	0 79	—	—	0 72	0 87	0 82	0 97	—	—
1300	—	1 70	—	—	—	—	—	—	—	—	—	—	—	—
1400	—	—	—	—	—	—	1 45	0 68	—	—	—	—	—	—
1500	—	—	3 10	1 90	—	—	—	—	—	—	—	—	—	—
1600	—	—	—	—	1 90	1 14	—	—	1 11	1 24	1 19	1 48	—	—
1700	2 20	1 74	—	—	—	—	—	—	—	—	—	—	—	—
1800	—	—	—	2 50	—	—	—	—	—	—	—	—	2 30	0 90
2000	—	—	5 60	3 0	4 60	0 96	2 40	1 95	1 54	1 65	1 61	2 11	—	—
2100	27 0	0 80	—	—	—	—	—	—	—	—	—	—	—	—
2200	—	—	—	—	—	—	—	—	1 87	1 87	1 85	2 48	—	—
2400	30 0	1 86	—	—	5 60	1 75	—	0 69	—	—	2 11	2 89	—	—
2500	—	—	8 70	4 60	—	—	—	—	—	—	—	—	—	—
2800	—	5 60	—	—	—	—	3 0	1 14	—	—	—	—	8 0	1 35
3000	—	—	13 60	6 40	—	—	—	—	—	2 32	—	2 96	—	—
3100	—	—	—	—	—	—	6 40	3 20	—	—	—	—	—	—

Before examining this table, it is well to remark that the figures in the Belgian column are taken from the reports of ten years of the practice at the Artillery School; the figures in the other columns represent special trials.

The attentive study of this document shows that the English gun is inferior to the Belgian in regularity of range, and a little superior in accuracy; but if we consider that the English gun was fired to show

specially its qualities, whilst the Belgian results are those obtained from the annual practice of the troops, we must conclude that the English gun has less accuracy than the Belgian.

Tir exécuté à Shoeburyness en Octobre 1871.

Tableau No. 6.

TIR COMPARATIF
des canons de 4 Prussien et Anglais.

Plan du terrain. Echelle de 0m,001 pour 1 mètre.

Distance : 2275 mètres. 4 rangs de panneaux de 18 mètres de front, 2m,75 de haut, 0m,05 d'épaisseur et 18 mètres d'écartement.

Prussien. 1re SALVE. (Sur 10 coups.) NOMBRE D'ECLATS dans les 4 rangs de panneaux. Rangs.	Traversant.	Incrustés.	Empreintes.	Total.	Anglais. 2e SALVE. (Sur 10 coups.) NOMBRE D'ECLATS dans les 4 rangs de panneaux. Rangs.	Traversant.	Incrustés.	Empreintes.	Total.
1er rang...	40	18	26	84	1er rang...	35	12	17	64
2e	5	6	5	16	2e	21	5	5	31
3e	2	—	—	2	3e	3	3	3	9
4e	9	7	26	42	4e	—	1	2	3
Total...	56	31	57	144	Total...	59	21	27	107

Tableau No. 7.

TIR COMPARATIF
des shrapnells de 4 Anglais à fusées percutantes et à fusées à temps (Boxer).

Coupe du terrain.

Distance : 2275 mètres. Mêmes panneaux.

3e SALVE. (Sur 10 coups.) NOMBRE DE BALLES ET D'ECLATS dans les 4 rangs de panneaux. Rangs.	Traversant.	Incrustés.	Empreintes.	Total.	4e SALVE. (Sur 10 coups.) NOMBRE DE BALLES ET D'ECLATS dans les 4 rangs de panneaux. Rangs.	Traversant.	Incrustés.	Empreintes.	Total.
1er rang......	4	2	1	7	1er rang......	1	3	—	4
2e	20	14	11	45	2e	86	8	6	100
3e	7	10	14	31	3e	70	8	29	107
4e	8	19	15	42	4e	45	22	33	100
Total......	39	45	41	125	Total...	202	41	68	311

This in effect has been acknowledged by the officers of the Committee at Shoeburyness, but they assert that the difference is very small, and that it is frequently reversed, and in general as the distance increases the English gun again takes the advantage. They say, not without reason, that in war the object is not to make a hole in a target, but that a projectile like theirs, with a flatter trajectory and a higher velocity than the Prussian, will be more destructive.

The trials at Shoeburyness were completely favourable to the English shell. It shows that it has an accuracy that no projectile has yet obtained, and it is considered that the effect of shrapnel shells with time fuzes constitutes an argument in favour of muzzle-loaders without which the time fuze must be abandoned.

The English gun is very easily loaded. Whatever may be the difficulties in the service of the gun, whatever be the inconveniences to which it is exposed, as the projectiles are so well made these defects do not approach the difficulties of the service of the Prussian and Belgian guns, and the care they demand.

Before practice with the Belgian gun, the captain of the battery chooses 12 shot and 12 cartridges; he weighs and measures each shot and cartridge, and marks the weight on each shot, numbering them from 1 to 12; he regulates his practice accordingly. The officers are supplied with regulated measures to assure themselves of the exact position of the shot in the bore. Experience shows that a centimètre too far back or too far forward will make a difference of 40 or 50 in the range. "Absurd minutiæ," some one may say, "and which could not be undertaken in war." So also think the English. They have taken equal care with their shells and cartridges; but there is a great difference between the English and the Belgian precision. The first stops in the arsenal, where it is a valuable quality; the second extends itself to the operation of loading—that is, to the field of battle—where it is a defect. Accuracy of fire is a precious gift which no arm possesses of itself; it is only acquired by ingenious and persevering care.

The report concludes with suggestions as to the future gun for France.

Two systems are before us—the English, which is derived from ours, and the Belgian—but neither could be introduced into France without modifications. None of our foundries are in a position to commence, with absolute certainty of success, the manufacture of *matériel* in steel. M. Krupp, in spite of the perfection of his manufacture, would have been unable to conquer the prejudices of the Prussian artillery without the patronage of the King of Prussia. Even now the authority of his Royal associate does not free him from attack. The Essen manufactory is subject, from time to time, to distrust. A 9-inch 8-ton gun burst this year at the camp of St. Maurice; more recently still, an 8-inch 12-ton gun burst at Cronstadt. These have shown that there never can be absolute confidence in steel, and that it will never support heavy charges.

The manufacture of the English gun gives the most complete security, but the price is not suitable to the actual resources of France. Not only each 9-pr. gun costs 3200 francs, but to produce them it would be necessary to put up a complicated machinery, which a fresh change

would render useless. It is, however, not impossible to follow the English system, preserving our bronze pieces and applying to them the Woolwich improvements.

Baron Berge then proposes to put a steel tube with the Woolwich rifling into the bronze guns; the other alternative is to adopt the Belgian gun. The report thus concludes :—

Of the two systems proposed, the first is that which offers the greatest security. Its adoption would be the most simple. It gives—if one can in such matters hazard an opinion—a certainty to realise at little cost the desired improvement. The second system appears destined to give greater accuracy. It has the inconvenience of preserving the embarrassments and troubles of a breech-loader, but it is in the line of progress.

Many artillery officers have changed their opinions since 1870, and would view with repugnance the continuance of a system of artillery and of theories to which they impute a portion of their disasters.

If these considerations weigh in the balance, they incline towards the second solution. But whatever be adopted, we must have recourse to improved workmanship, and manufacture the ammunition after the newest methods.

LONDON,
October 25, 1871.

ARTILLERY LESSONS

FROM

THE SIEGE OF STRASBURG, 1870.

BY

CAPTAIN F. C. H. CLARKE, R.A.

The more the history of the last campaign becomes known to us from authentic sources, the more unquestionable do the claims of the Prussians appear to the designation of a practical people.

When we find that the whole arrangements for opening the recent campaign were sketched out by the Prussian Staff in the winter of 1868–9 in the most minute detail—that lines of rail were allotted to the separate army corps, and that time tables, showing the times of departure and arrival of each separate regiment, squadron, and battery at the points of concentration in the Bavarian palatinate, were drawn up, and which merely required the first day of mobilisation to be signified by the king to make them complete—and moreover, that these arrangements were followed, with but slight modifications, in the actual campaign—with what result we know—their preparations for war strike us as almost appalling in their completeness.

As in great things, so in small, nothing is left to chance; all that is intended to stand the rude test of war is patiently and practically worked out in time of peace.

The communications of General von Decker, who commanded the artillery at the siege of Strasburg, to the military journals in Prussia, with reference to that siege, are full of interest for artillerymen; and it is proposed in this paper to illustrate the effect of modern weapons on siege warfare by references to his remarks. With this view, a tolerably free translation of those parts of his communications which bear upon the application of "curved fire" for breaching and demolition has been made.

In the present day of long-range rifles, batteries intended for breaching purposes have to be opened at much greater distances from the work to be breached than heretofore, and the besiegers thereby labour under the disadvantage of being unable to see the object at which they have to aim. A very careful study of the plans of the fortresses, and a perfect acquaintance of artillerymen with the power of their guns, as deduced from the practice tables, must be brought to bear, to produce the best results.

Every artilleryman knows the difficulty of making an efficient breach by curved fire with the present elongated projectile. In order that the shell may just *lob* over the glacis, and hit the escarp wall sufficiently low down to form a practicable breach, the projectile must have impressed on it a high "angle of descent;" and this high angle of descent necessitates, at the ranges at which breaching batteries are opened, a high angle of elevation, and consequently a small charge. This small charge, as is well known, is productive of a "wabbling" in the flight of the projectile, accompanied with slight penetrative power. It is consequently of importance to select the sites for breaching batteries at those distances (consistent with local requirements) from which the best effect from the gun can be produced. If tables were prepared, giving the penetrative force corresponding to the angles of descent at different ranges and for different charges, the artilleryman could see at a glance the best distance of his battery to meet the object in view.

At the siege of Strasburg, the Prussians used for breaching purposes the short 15 c.m. (6-in.) gun, firing a special long shell weighing about 60 lbs. They had carried out a series of breaching experiments with this gun at Silberberg, in 1869, and the experience gained from these trials, General von Decker tells us, proved exceedingly useful in the conduct of the siege.

The method of breaching employed at Strasburg did not differ from that which is well known—*i.e.*, a horizontal cut was made at a height from the bottom equal to one-third of the wall, and when this cut was supposed to be satisfactorily effected, vertical cuts (if necessary) were made, first at the two ends of the horizontal cut, and subsequently at intermediate points, the continued firing eventually bringing down the wall. Of course they could only conjecture when the horizontal cut was satisfactorily completed, but they could draw fairly correct inferences from certain phenomena exhibited at the practice ground at Silberberg, and which were found to be indicative of a successful breach.

(1) The concussion and explosion of a shell has a hard sharp sound if it hits solid masonry; on the other hand, it has a hollow and faint sound if it hits masonry either wholly or partly broken through—in this latter case the shell exploding in the earth behind the wall.

(2) Fragments of stone are hurled into the air as long as the masonry resists.

(3) The smoke from the explosion of the projectile soon rises above the wall, is of a blueish tinge, and forms a "ball" if the masonry remains intact. If the masonry has been broken through, the smoke appears after some delay, is darkish grey in colour, and rises slowly, as if coming from a chimney-pot.

General von Decker states that account was taken of these phenomena at Strasburg, and that when satisfactory appearances were observed, the "vertical cuts" were proceeded with, and generally effected in a short space of time.

There were two breaches in Strasburg which were nearly or quite practicable:—(1) Breach on right face of lunette No. 53. Took four days (14–17 September). About 1000 rounds were fired, each gun firing at the rate of 50–70 rounds per day of 12 hours (7 a.m. to 7 p.m.) Unfavourable weather, and a want of training on the part of the gunners, delayed the com-

pletion of the breach. (2) Breach on right face of bastion No. 11. Took 18 hours, during which time 600 rounds were fired, being at the rate of 6 to 7 rounds per foot run.

General von Mertens, immediately after the capture of the town, reported the breach in No. 53 lunette as practicable after a little clearing. Breach in bastion 11 was reported quite practicable.

It is proposed to give a translation of General von Decker's papers, so far as they relate, 1st, to the formation of a breach in lunette No. 53; 2nd, to the bombardment of the sluices.

It may be first premised that the method of getting the range in each case was the same. The distance of the battery from the work being known from the map, and profiles of the fortress being at hand, the amount of charge, &c., due to the required "angle of descent" necessary could be found from the range tables. The next thing to be done was to select some visible part of the work, and by firing a number of rounds, to find the "point of mean impact" of the group. By consulting the plans of the fortress, data could be obtained by which the necessary amount of decrease of elevation of the gun and of deflection could be calculated, so as to hit the part where the breach was to be made. In this way the "point of mean impact" of the first group of hits was transferred to a terminal point of the horizontal cut in the case of lunette No. 53, and to the face of the sluice in the other. Having thus commenced the starting point for the breaching at one end of the horizontal line, the "point of mean impact" could subsequently be transferred to the other end, &c., &c.

1. *Breaching Face of Lunette No.* 53.

In the night of 11th–12th September, the third parallel, about 630 yds. in length, was thrown up in front of lunettes Nos. 52 and 53. It was decided to effect a breach in No. 53. With this view, No. 8 mortar battery was converted into a gun battery, and armed with four short 15 c.m. guns. The distance of the battery from the crest of glacis of the lunette was about 800 yds.

The angle which the line of fire made with the face of the lunette was 55°. This was 5° less than the minimum angle at which a breach can be made satisfactorily, but it would have been difficult to get a better site, owing to the obstacles presented by the houses and gardens of Schiltigheim. The angle of descent of the projectile to hit the wall about 2 ft. above the water level, was found to be 7° 45′. The charge of powder, 1·7 lbs.

At 7 a.m. on the morning of the 17th September, No. 8 battery opened fire. The distance was obtained with greater exactness by firing a few rounds with full charges at the parapet at the head of the work, and was found to be 910 yds. Practice was then made against the visible part of the parapet with charges of 1·7 lbs., and the "point of mean impact" afterwards transferred sidewards and downwards. The effect of the shells was watched by a range party placed in a trench between the second and third parallel, whence the glacis could be seen, but not the wall to be breached.

The determination of the range took much time. As there was no telegraphic communication between the range party and the battery, the "cor-

rection" after each discharge had to be sent by means of a chain of posts along the trenches. The elevation finally determined was $7\frac{1}{8}°$. It varied to the extent of several sixteenths, on account of heavy rains and other meteorological influences. The guns were laid with quadrants. The range was determined about noon, and the horizontal cut was at once commenced.

When the horizontal cut was about half completed, a report was brought in that the system of countermines in front of the lunette had been penetrated by a gallery driven from the 3rd parallel. From the opening of these galleries in the counterscarp the whole of the breach could be observed, and it was seen that the lowest point of impact of the shells was about one or two feet above the level of the water, as intended. The breaching fire was continued for four days.

The continued breaching did not form a perfectly horizontal cut; for in consequence of the shells straying upwards, the whole of the wall was demolished by degrees, and while the lower parts were being gradually cut through, the upper parts were destroyed, great masses falling down, succeeded by earth. It was therefore not necessary to make vertical cuts. A large number of shells were fired into the earth of the parapet, to bring it down.

The breach had a slope of about 35°, and if a little more of the earth of the parapet had been brought down, the breach would have been practicable. The breach was entered on the 20th September, when the lunette was found to be deserted.

2. *Bombardment of the two Sluices.* (*Vide sketch*).

One of the chief sources of strength of the fortress of Strasburg consists, as is pretty well known, in the obstacles presented by its wet ditches and by the extensive inundations which can be formed in its vicinity.

By damming up the Ill and utilising the existing system of sluices, the French had not only filled the ditches of the fortress with water and inundated the whole country opposite the south front, but also a great part of the ground on the left flank of the attack, thereby considerably increasing the difficulties of the besiegers' approach.

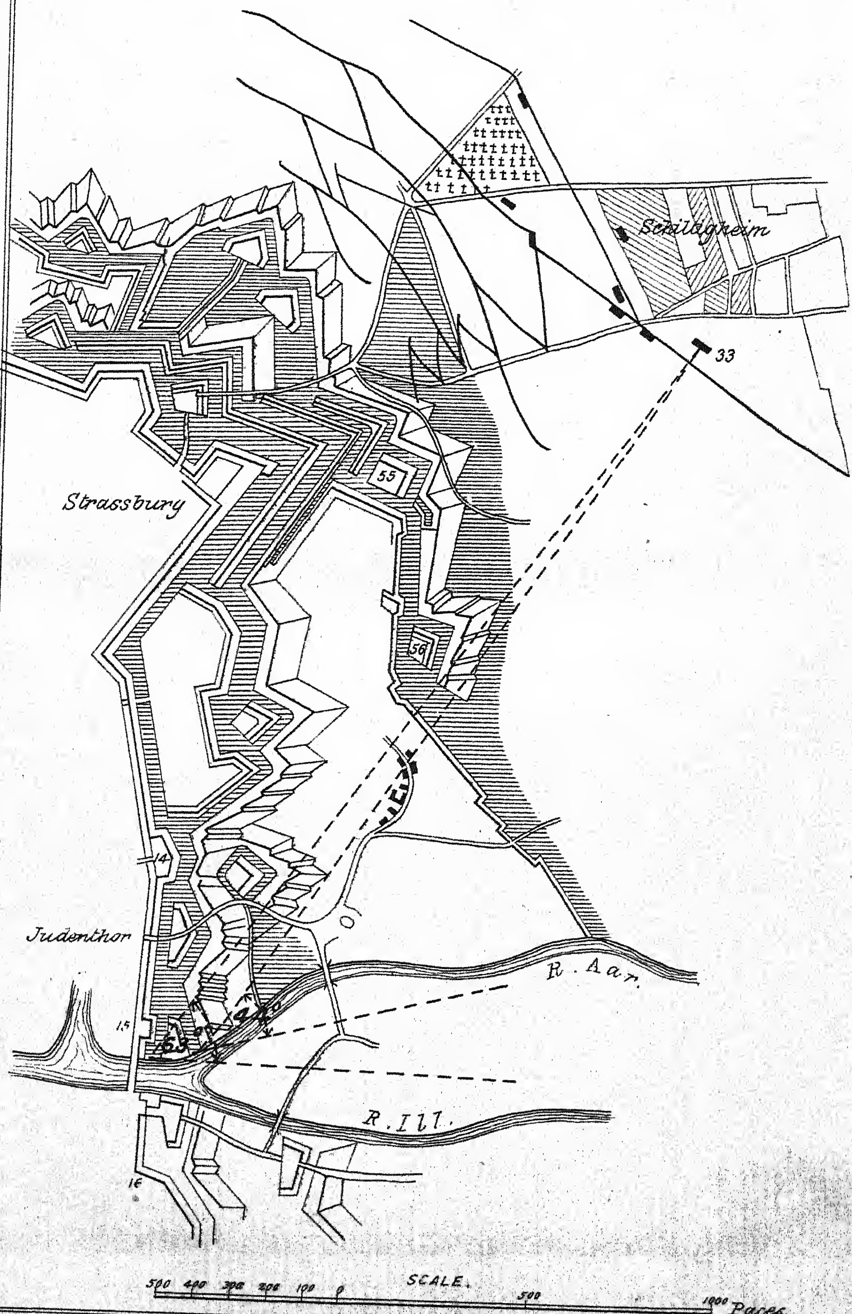
The existing plans of the fortress showed that the retention of the water in the ditches, and the swamping of the ground in front of the attack, was mainly effected by two sluices, one of which was situated in front of the curtain 15–16, and the other in front of lunette 63. By the destruction of these two outlet sluices it was hoped that the water on the attacking ground and in the ditches would be, if not actually drained, at any rate reduced to a very low level.

Neither of the sluices could be seen from any part of the attacking ground. The inaccurate maps would not have afforded sufficient data to undertake the bombardment from the first parallel with any chance of success, had there not been an engineer officer (Captain Kirchgessner, of the Baden service) present at the siege, possessed of local knowledge, who could supply the necessary information.

Under these circumstances, the officer commanding the siege artillery resolved at any rate to make the attempt. It was not deemed advisable to form a special battery for the purpose, but it was considered sufficient to

SKETCH TO ILLUSTRATE THE BOMBARDMENT OF THE SLUICES AT THE SIEGE OF STRASSBURG.

SEPTEMBER 1870.



tell off two or three guns of one of the batteries already existing for this special duty. The battery selected was No. 33, occupied by two companies of the Magdeburg regiment of garrison artillery (No. 4), which was armed with eight 15 centimetre steel guns.

The first point was to determine the situation of the sluice in front of curtain 15–16, distant about 1950 yds. from No. 33 battery. Captain Kirchgessner first pointed out as a datum point a turret, supposed to be close by it, on the wall. A few rounds were fired, but the result showed that this could not be the turret in question, and the firing was resumed at another turret, which was hit after a few shots. This turned out to be the right one. A number of shots from each of the two guns was now fired at the exposed face of the turret, in order to determine as accurately as possible the "point of mean impact" of the group for each gun. The projectiles used were the ordinary shells, the charge being $2\frac{1}{4}$ kilos. (5 lbs.) By applying the necessary corrections to the elevation and deflection, the "point of mean impact" was transferred to the middle of the face of the turret. The lines of fire on the turret being determined in this manner, calculations were made, based on the drawings of the fortress profiles and the local knowledge of Captain Kirchgessner, for transferring, by corrections of the elevation and deflection, these lines of fire to a point on the sluice just above the water-level in the ditch. The middle of the face of the turret being a fixed point in the plans of the fortress, the distance of any part of the sluice also shown on the plans could be determined from it. Consequently a calculation could be made as to what amount of decrease of elevation and what amount of deflection would be necessary for the "point of mean impact" to be transferred from the middle of the turret to the middle of the sluice.

The guns being laid in this way, the bombardment commenced.

Now came the question as to whether they hit the sluices or not. A reference to the practice tables showed that at this range about 8 or 10 per cent. of the projectiles might hit, if the guns were correctly laid on the sluice. With the naked eye it could be seen whether the shells hit the water, by the "sheaf" of water which was thrown in the air; and by a comparison of the position and height of the "sheaf" with the position of known objects in the fortress, inferences could be drawn as to where the shot struck. With a good glass it could be seen whether this sheaf of water was accompanied with a shower of wood or stone splinters. When this occurred it was concluded that the sluice was hit.

The necessary corrections were finally applied, and the fire of the guns was directed so that the "point of mean impact" of each gun should strike the face of the sluice about 13 ins. apart, from which arrangement it was expected that the cones of destruction formed by the two shots would meet. When it was at all doubtful whether the projectiles were hitting the intended mark, shooting was resumed at the turret, being a visible object, as a check, in order to apply any correction which might be necessary on account of the weather, &c.

The obtaining of the range of the sluice in front of lunette 63 was done in a very similar manner, but under less favourable circumstances. In this case the shooting was directed on the exterior slope of the left face of the lunette 63, and the exposed face being of less height than the turret, fewer hits could be obtained on it in proportion, and it was more difficult to

determine the hits precisely. From a great number of shots the "point of mean impact" was determined, and the line of fire so obtained was transferred to the middle of the exposed face of the sluice in an analogous manner to that described in the case of the other sluice. The visible point from which the line of fire was transferred sideways was the salient angle of the lunette, which was shown on the plans of the fortress. As a check, and in order to apply the correction due to the weather or other influences, the shooting was resumed against the face of the lunette from time to time.

The angle of the descent of the shot was about 7°; the line of fire formed with the face of the sluice in front of the curtain 15–16 an angle of about 63°, and with the sluice in front of lunette 63 an angle of 44°. The final velocity was about 918 f.s., which was sufficient to obtain deep penetration.

In order to prevent any repairs being carried out by the French, the besiegers fired shrapnel from time to time, especially by night.

In the manner thus described, the bombardment was maintained with two guns against the sluice in front of the curtain 15–16, and with one gun against the sluice in front of lunette 63. The effect of this fire might be inferred from the conduct of the besieged, who concentrated a heavy fire from their batteries on these guns.

After the fall of Strasburg, it was seen that these sluices were very strongly built. The stone-work was composed of huge cut stones, and about 6 ft. thick, and the wooden sluice-gates were of the smallest possible dimensions. The bombardment had nearly destroyed the wooden sluice-gates, and had displaced or destroyed the stone-work. In order to repair these damages, the French had used heavy timbers and some 50,000 sand bags and corn sacks filled with earth, stones, &c.

The water in the ditches had been visibly lowered, but the early surrender of the fortress relieved the besiegers of any further care in this respect.

June, 1872.

THE

DEVELOPMENT OF ARTILLERY TACTICS

IN COMBINATION WITH THE OTHER ARMS.

A Lecture delivered at the Prince Consort's Library, Aldershot, on the 27th March, 1872,

BY

CAPTAIN FOX STRANGWAYS, R.H.A.

In now submitting this paper to a larger number of my brother officers, I have thought it better to leave out certain portions of merely local application. There may still be some illustrations which are hardly intelligible without plans to those unacquainted with the ground, but to have altogether omitted them would have left the paper very bare of illustration, and have considerably altered its bearing and scope.

I propose in discussing the subject I have chosen, to dwell mainly on the tactics of field artillery, as they have been and must be further modified by recent changes in arms, to consider the probable direction of changes in tactics in the immediate future, to ascertain how far our own practice is based on true principles, and where there may seem to be errors, how they may best be corrected.

I shall illustrate what I have to say from the action of artillery in recent campaigns, but chiefly from the manœuvres of last autumn, and the ground round the camp. There are various reasons for this. In the first place, it is very difficult to get minute reliable details of the employment of artillery in the field. Contemporary writers treat the subject either from the picturesque or from the strategic point of view. The wars of 1866 and 1870 have given us a rich harvest of newspaper correspondence admirable for its particular purpose, and inestimable as material for the future historian, whilst there have been also works of all sizes and pretensions throwing a flood of light upon the general operations of the campaigns, and even the larger tactics; but the actual disposition and handling of the troops in combat, so far as I can ascertain, has been lightly touched by these numerous writers. Of all arms the artillery has been the worst used in this respect, and thus it comes to pass

that although certain broad principles of tactics seem to come out, very little detailed illustration can be given from the last campaigns.

The tactics of field artillery are governed chiefly by three considerations:—

Mobility.
Efficacy of fire.
Shelter from the enemy's fire.

Before attempting to estimate the position in which we now stand, and to deduce the principles on which the employment of the arm should now be founded, it will be convenient to take a very cursory view of the progress of artillery, or rather to notice certain landmarks in its history which have for a longer or shorter time influenced its application in the field.

Until quite the end of the sixteenth century, the heavy and rude construction of the carriages, the length of the guns required to develop the power of the ill-made powder, the long trains of wagons with ammunition, rendered artillery of little use in the field. Tactics were then of the most simple nature. If the guns could be dragged into a position in the line of battle by the hired or pressed transport of the country—the only means of locomotion available—and a few rounds fired from them, it was all that could be expected. A second movement was rarely practicable, and in the event of retreat the guns were generally captured, and I dare say the generals were not sorry to see the last of them.

The first attempt at a really movable artillery was made by Gustavus Adolphus, early in the seventeenth century. He introduced light iron guns drawn by two horses, and first made cartridges, by which means he obtained a much greater rapidity of fire—guns having been previously loaded with loose powder, by means of a ladle. This was a distinct advance in artillery, and led to some development in tactics. Guns were now divided, and placed in the centre and on the flanks of the line.

It was not, however, till the latter part of this century (the 17th) that a special corps was raised in any country. Until this time the gunners had been cosmopolitan. Their art was considered a purely mechanical one, they were apprenticed to it in limited numbers, and their services were at the disposal of any prince who needed them. This evidently tended in large measure to the ill repute of the arm.

Louis XIV. first raised a regiment for artillery service, and from this time in all the conntries of Europe artillery *matériel* progressed until the time was ripe for the next great step which influenced tactics. This was the introduction of horse artillery on the detachment system by Frederick the Great, in 1759. The idea, however, was slow in taking root, and it was only after the French revolution that the use of horse artillery became general. Through this, and the improvements in *matériel*, mainly due to Gribeauval, in France, artillery was ready for the system of handling brought to the greatest perfection by Napoleon, and continued with little modification to our own times, of which the main characteristic was the rapid assembly of large masses of artillery for a decisive effort, the bringing an overwhelming fire to bear on the vital point.

The immense development of mechanical science in the latter half of this century, and the invention of rifled guns, have now brought us to another landmark, probably more important than any that has preceded it. How

far this will influence the accepted tactics, either in principle or detail, and what are the points to which we Englishmen ought especially to direct our attention, are the subjects to which I shall now address myself.

In discussing the question of mobility, I shall consider only horse artillery and the ordinary field batteries, armed as they are, or will be in the immediate future—the horse artillery with 9-prs., the field batteries with 16-prs. There may be of course in particular countries, and with reference to particular operations, both lighter and heavier guns brought into the field, but the principles which govern their disposition and movement will be the same, however the details may vary.

It may be said broadly that mobility, in the sense of actual quickness of moving, has not been increased by our recent changes. What we have gained by the progress of science has been given to increased power in the gun, and the actual weight behind the horses has not been lightened—in fact, in some measure it has been increased. It is, however, evident that a very real mobility has been gained, for a machine of vastly increased power can now be moved at the same, or nearly the same, speed as the inferior guns of a former time, and the effect produced in a much shorter time, over a larger space, and with an exactness hitherto unknown. The conflicting elements of weight and power are of course important, and within certain limits will always be subjects of controversy. Some are of opinion that we have rather overstepped the limit of weight. However this may be, whether our guns might be a little lighter or not, there can be no doubt that their mobility, in the true sense, is greater than anything we have had before.

There it a true and a false mobility; I am afraid our whole system and training has led us to attach importance to a kind of mobility which, although brilliant and effective at field days, cannot stand the test of service. It is not the power of galloping a few hundred yards into a position, blazing off a few rounds, and dashing off again, *ventre à terre*, to another position, differing from the first only in being a little worse; nor, again, is it the power of rapid movement on the part of guns only, which constitutes true mobility. True mobility must comprehend the movement of every part of the machine—guns, gunners, and ammunition—and must take account of the necessity of keeping up the movement over long distances, in all kinds of ground, in spite of obstacles, and with all the disadvantages of casualties and loss of condition in horses.

The most movable artillery is that which can get soonest and safest to the point from which it can deliver an effective fire.

There is no use in getting three or four miles to a flank, and then finding half a mile of deep ground up hill before you, and your horses dead beat. It is little comfort to say you did not know it was so far. Something should always be kept in hand to meet miscalculations and difficulties. Nothing is gained, even in short distances, by hurry in taking up a position. The general result of galloping into it is that the guns are not placed to the best advantage, and are unnecessarily brought under fire. It is rarely of consequence that a position should be occupied a few minutes sooner or later. At field days there is often an impatience to see troops moving, but almost the only occasion on which hurry can be necessary, or even desirable, is when a movement in the nature of a surprise has been undertaken. When artillery has been detached to occupy a position on the flank of the enemy, and its ap-

proach is discovered, moments are important to establish a fire before he can alter his dispositions to meet it. I do not in the least overlook the importance of securing the initiative of fire on every occasion, but I maintain that it is more possible to secure it by secrecy than by dash. In the case of a direct attack, it is only possible by secrecy. The enemy knows the range of all the positions that can be taken up by artillery, he is on the look out for every indication of their being occupied, and as soon as artillery is seen coming wildly over the crest, he pours in a storm of shell which probably puts several guns *hors de combat* before they even unlimber.

This importance of the initiative of fire was well understood by Napoleon, and was one of the causes of his great success with artillery. I think it was at Austerlitz that the French artillery under Senarmont, although inferior in number of guns, prevented the Austrians, who came up by degrees, from ever getting their guns into action. So, in a pamphlet by Captain Laymann, of the Prussian infantry, there is evidence to show that the initiative of fire established by the Austrian artillery was one of the main causes of the comparative failure of the Prussian artillery in the campaign of 1866.

It is sometimes possible, however, to take up a position so quietly, by running the guns up by hand (where the ground is not very steep)—at all events by exposing the smallest possible number of horses, that the guns may be able to open fire before they are discovered.

From what I have said of the true mobility of artillery, the proper place and use of horse and field artillery follows. As at present organised, our field batteries are not capable of moving out of a walk with any degree of efficiency, except for very short distances. The gunners must be left to toil behind, as but three, or at the most four, men can be taken with the gun. Witness the well-known case of Turner's two guns at the Alma, which arrived in position on the flank of the Russians without gunners, and were served by a brilliant staff of artillery officers who were on the spot, and fortunately had nothing else to do. By the introduction of axle-tree seats, we are on the eve of increasing the mobility of the field batteries, which may possibly be still further increased by mounting men on the off horses of the gun teams.

I hope to see the mobility of field batteries increased to the utmost extent possible. I believe it to be the direction in which the greatest practical reform is now to be made, and it will double the power of the artillery that first takes it in hand. Some people have supposed that upon this level might be created a field artillery in substitution of both our present horse artillery and field batteries. This by no means follows. A very slight consideration of the respective uses of horse artillery and field batteries, will show that they stand upon different ground, and that the necessity for both is unassailable. Horse artillery is required to act with cavalry, supported by and supporting it; to accompany it in long and rapid reconnaissances, to execute long flanking movements extending over many miles of ground, and generally to act with freedom and rapidity on the wings, and in pursuit, and in retreat. Field batteries are, or should be, equally mobile on a confined area, and mounted detachments would be superfluous, and even mischievous, for all the ordinary purposes of the line of battle, and working generally with infantry. Fewer horses are exposed to fire, and the cost of raising and maintaining, and difficulty of foraging is greatly diminished. For these reasons the bulk of the artillery must always be field bat-

teries; but those who advocate the abolition of horse artillery on the detachment system have to meet this difficulty: whatever system of carrying the gunners is adopted—limbers, axle-tree seats, trail, off horses—the weight of the gunners must be added, *i.e.* 7 or 8 cwt. Can it be maintained that this is a trifle? We know and see every day the difference that 5 cwt. makes to the horse artillery with the present gun. Whatever mobility may be attained without the mounted detachments, the detachments have always got the 7 or 8 cwt. in hand, and it can be put on a more powerful gun, and an increased number of rounds in the limber. The extra weight, in fact, gives a margin within which the machine may be perfected, irrespective of any question of sufficient rapidity of movement; and although horse artillery on the detachment system is unnecessary and too costly for universal use, it cannot be dispensed with for certain most important purposes of war.

The more the power of artillery is increased, the more it becomes necessary to give the arm a wider development on the field of battle. The particular gun which combines best the somewhat conflicting requisites of power, accurate shooting, capacity of shell, number of rounds carried, and lightness, must always be a difficult question, but whatever gun is selected, mounted detachments separate from the gun must always give a power of moving further and faster.

I contend for the greatest freedom of movement, and the utmost rapidity possible over long distances; but the actual moving under fire, and into position, should be done with deliberation, in order that there should be the least possible exposure of men and horses. Every fold and dip of the ground must be taken advantage of—not of course pedantically, and to the sacrifice of valuable time, but with an eye to the easiest and most sheltered line of advance. Positions should be well reconnoitred beforehand, and the very best spot for each gun carefully chosen, that there may be no further movement afterwards. A few minutes given to the choice of a position may save a battery from annihilation.

What are the best positions for guns, and how is the greatest effect of fire to be obtained? It is a popular notion that guns should always be on the tops of hills, and never far removed from the other arms. Thus we see, over and over again, at field days, guns placed on steep contracted knolls, with no single advantage, six guns placed where there is properly not room for two, limbers and horses jammed up together, so that a single shell would create a panic. We see also unseemly contests for room between artillery and infantry. A little consideration will show that rifled guns have given artillery a new zone, so to speak, behind and on the flanks of the other arms, in which it is entirely unhampered and free to select any ground. Assuming infantry fire to be effective at 900 yds., artillery has a zone nearly a mile wide, in which it has nothing to interfere with it, and it must not be forgotten that, even when exposed to attack, it may be defended by the flanking fire of other guns and of infantry at considerable ranges, and may be as safely placed as in actual contact with the infantry. To illustrate what I mean, I will cite a recent field day:—A supposed enemy, coming from the north, had driven the division from Miles Hill, and the south bank of the canal. A new position was taken up, and a brigade of infantry and several batteries occupied Long Hill. Surely the slopes immediately below Cæsar's Camp would have afforded an admirable and safe position for some guns.

They could not have been attacked across the front of the infantry, and could only have been dislodged by an attack upon their flank in turn, which would require time and fresh dispositions. The guns and the infantry support each other, though separated by 800 or 900 yds.

The requisites of a good position for artillery are simple enough. It should have a moderate command over the point at which the fire is to be directed, should be easy of access from the point of approach, afford direct cover for the limbers and horses, as well as protection from being easily taken in flank or in reverse by the enemy's artillery. The ground in front should be unfavourable for the action of the enemy's projectiles; for instance, with a steep bank or declivity to the front (which would catch many shells falling short), broken ground, or marshy ground. The capture of Balaclava affords an instance of the slight effect of shells in marshy ground. A battery of horse artillery came into action at the head of the harbour against the fort, in which the Russians had some little coehorn mortars. They of course knew the range accurately, and threw 20 or 30 shells amongst the guns. These all burst very well, but did nothing more than throw a little mud about. Absolute hollows should be avoided for the limbers, as they may prove shell traps. The need of moving the battery to the front without making a long detour must be remembered.

Few positions, of course, are good in all respects. The choice requires a good tactical eye, which is able to strike the balance quickly, and decide on the points which ought to have most weight. For instance, when near the enemy, and apprehensive of attack by infantry, broken ground in front would afford cover to the attack, and would cease to be an element of good in the position. The most perfect shelter of guns and gunners, and easy ground of retreat, become then predominant considerations. In such a position, an easy slope to the rear, allowing the guns to be run back and limbered up without bringing the horses under fire of infantry, is valuable. On an exposed flank, the immediate neighbourhood of a wood is dangerous.

So far I have treated of considerations which, although they should be understood by all officers—for without knowledge of them there cannot be intelligent co-operation—yet are mainly the business of artillery officers themselves. I now come to the larger and more generally important question of the general handling of artillery in the field. It will be convenient to treat this from the separate points of view of the attack and defence. In the reconnaissance of a position preparatory to attack, it will probably be necessary to use artillery to force the enemy to display his position. If anything is really to be gained by this, he must be pushed with some force. We generally see horse artillery used in our manœuvres for this service. As the whole object is to draw fire on the guns, and force the enemy to shew his hand, it must be a mistake to use horse artillery, and run the risk of crippling it before its hour arrives.

When the point of attack is decided, the artillery must prepare the attack, concentrating its fire on it, and maintaining it with vigour to the latest moment, directing it when the attack is fully engaged on the enemy's reserves. The accuracy of rifled guns enables the fire to be kept up over the heads of the assaulting troops almost to the moment of contact.

To concentrate a fire means now, more than ever, to disperse batteries. By dispersing the guns over the artillery zone that I have spoken of, you obtain

largely increased power over the ground occupied by the enemy. From a position directly in face, you often see but the muzzles of the guns of a battery: by going 300 or 400 yds. to the right and left you open the limbers of the flank guns. By posting the guns on different points of the semicircle over which you range, you open up numberless hollows and folds of the ground in which troops are placed, creating a general fidgettiness and sense of insecurity, and exerting a moral effect by the number of points from which the fire proceeds, which is wholly wanting when the guns are massed in large batteries. In many accounts of the battles of the late war, stress is laid on the way in which the French were disturbed by the unexpected places from which the Prussian artillery opened fire. At the same time, the fire is fully concentrated on the desired point, and the guns themselves are far more secure because not crowded in a place unfit for them, but placed at wide intervals. On this point I will notice a prevalent idea which I think an error. It is said that one gun should never be placed alone, under any circumstances. This is founded on the notion of maintaining a constant fire, to prevent an enemy rushing upon a gun when unloaded—true, to a certain extent, with smooth-bores at close quarters, though exaggerated then, but absurd with the longer ranges of rifled guns, and especially so in the case I am now considering, of a distant fire preparatory to attack. Suppose the crest of a hill affording good positions for four guns, at intervals of 20 or 25 yds., but no other place except spots for one gun each, 80 or 100 yds. on either flank. It would be ridiculous not to place the guns there; they are parts of a huge battery of perhaps 100 guns, extending over miles of ground, and the thing wanted is to place each gun best, whether alone or not. Two guns well placed, carefully served, with every round telling, are worth six exposed to fire and hurriedly served. Nothing is a greater mistake than to cram more guns into a position than it will bear. I believe that one of the things most borne in upon Prussian artillerymen in the late war, was the necessity of taking very large intervals between their guns and limbers.

I want to make myself understood upon this point. Excessive dispersion of guns without a definite and important object entails many evils. The battery is the tactical unit, and as a general rule it will be most convenient to keep it together; but just as there are occasions when large masses of guns may be concentrated, so there are other occasions when the guns of a battery may be more widely separated than usual. To make a fixed rule that one gun is never to be alone, and to carry that out, in a narrow sense, is to create mischief and confusion.

There may be occasions when guns will be massed together in considerable numbers, but the introduction of rifled guns must tend to make them very rare. Fire can now be concentrated from points in such a large arc, and with so much more effect than by the direct concentration of the guns themselves, that the disadvantages of massing guns appear more prominently. These are, that they interfere with the action of the other arms, and are vulnerable to the attack of skirmishers in an especial degree. Further, if the country is not very open, the mass of carriages in advance or retreat has to pass by one or two roads, bridges, or defiles, thus causing delay and difficulty.

The Prussians discovered the power and freedom given by rifled guns working on the flanks. At Sadowa they stuck to their old principles, and tried to get to the front in the centre of the battle. They could not find

room, and did nothing. In the French war, the guns were much more on the flanks; notably at Sedan, where the batteries on the flank and rear of the French above Floing were a marked feature of the battle.

Guns may often be pushed forward on the flanks so as to overlap the enemy on both flanks, and squeeze him out of a position. If there is any ground for artillery on the flanks within range—that is to say, a mile, or a mile and a half on either flank—this is perfectly safe. If the guns can find a position to annoy the enemy seriously, he must either penetrate between them and the main body to cut them off, make a direct attack on them, or again outflank them. He cannot attempt to cut them off without getting squeezed between them and the guns with the main body. If he makes a direct attack, or flank attack on the outer flank, his whole position of defence is shaken, to say nothing of the loss of time in making his dispositions for attack.

The position at Frensham, between the Great and Little Ponds, facing east, is an example of what I mean. An attacking force at Kettlebury Hill could outflank it, both right and left, concentrating an artillery fire on the rear of the position from Lock's Hill and the ground above on one flank, and the hillocks beyond the Devil's Jumps and towards Greyshot Down on the other. All the forces support each other with artillery fire. The Frensham force cannot move across the common without the risk of being crushed between all three, or attack either flank without in turn exposing itself. The radical fault of the position is, that whether occupied compactly or with some extension, its flanks and rear are insecure against an active artillery, without an immense extension, whilst the openness of Frensham Common in its front, which is an obstacle to direct attack, is also an obstacle to counter attack.

The full development of the power of rifled artillery will, I believe, only be attained by still bolder movements on the flank and rear of an enemy, sending guns with strong escorts to make long detours to seize positions from which the whole position of the enemy may be shaken. There is always such ground to be found by a tactical genius, and even where the real effect of the fire may be comparatively trifling, the moral effect created by the sudden and unexpected appearance of a force of doubtful strength in a dangerous neighbourhood will go far to loosen the hold of the enemy on his main position. These extended flank attacks of artillery will of course be combined with the determined attack of the main position. They are no doubt to some extent dangerous—the force may be thrown upon an eccentric line of retreat, cut off from the main body, sometimes sacrificed altogether; but the possible results are so brilliant that a general who thoroughly understands the power of rifled guns will not hesitate to develop his tactics in this direction. Horse artillery find one of their main uses in these extended movements, but to gain the full advantage of the freedom of artillery, we must, I think, alter our system of escorts. The escort of a battery now is ludicrously insufficient. A troop—at the most a squadron—is sent with a battery of horse artillery. What use is it? Any attack made on the battery by cavalry would be made most certainly in superior force, and against a few infantry skirmishers the battery is powerless. The escorts of detached batteries should always, when possible, be composed of both infantry and cavalry, and should be of sufficient strength to hold the front and flanks of the battery against sudden attack. The escort is the eye of the battery, and should, by its skirmishers, search and overlook all the ground on the front and towards the flanks, particularly the most exposed

one, so that the commanding officer of the battery will be relieved of all fear of sudden and unperceived attack, and free to devote himself entirely to the effect of his own fire. It is impossible to lay down absolute rules for the strength of escorts; they must depend on the service for which the artillery is required, and the degree to which it is separated from the main body. Probably, when separated at all, the escort ought seldom to be less than half a battalion of infantry and two squadrons of cavalry. What can be more absurd than when a battery has got into a good place, and established a fire on the flank of the enemy, to see it obliged to retire before the fire of a dozen skirmishers?

I know that the subject of escorts is rather an unpopular one. Commanding officers and brigadiers dislike their regiments and brigades being weakened; the officers who command the escort consider it a disagreeable and inglorious duty. Opinions differ as to the formation of the escort. The author of the "Tactical Retrospect" is strongly in favour of a special and permanent escort, but a recent pamphlet which many in this room may have read, by the Prince of Hohenlohe-Ingelfingen, the Commandant of the Brigade of Artillery of the Prussian Guard, is as strongly against it. I believe that although there are many advantages in accustoming the same bodies of troops to work together, the practical difficulties in the way of a permanent escort would be very great, and that it would be better to form it on the spot for the particular service required. I have spoken of the force as an escort, and this, perhaps, rather conveys the idea of a small force, entirely subordinate to the battery; but it is obvious that it might often be of very considerable strength, and that the officer commanding might or might not be the artillery commanding officer. The reason I speak of it as an escort is that I suppose the artillery attack to be the main object, the other troops being only for the protection of the artillery, though of course the dispositions for defence would rest with the senior officer. I feel sure as the subject is considered and discussed, whatever there may now be of prejudice will give way, and it will be seen that the whole benefit of the invention of rifled guns depends on their latitude of movement, that there cannot be this without security from attack and capture, within reasonable limits, and that the part of both guns and escort in the critical flank movements of which I have been speaking is of the highest importance, and one that offers the highest opportunities of distinction to both. It is of course impossible that in very rapid and extended operations an infantry escort can accompany horse artillery. I only say whenever it is possible the three arms should be together, and infantry should always follow if there is a hope of their being able to get up.

The advance of the artillery on a position after it has been stormed, is rendered more difficult by the increased range of guns. When guns used to fire at 700 or 800 yds., it was easy to see when to limber-up and advance. Now that the guns are probably firing at two or three times that range, they may, after supporting the attack from their first position, either not see the right moment to advance, or be delayed by the length and difficulty of the ground they have to traverse, so that the infantry, after their first success, may find themselves again in face of the enemy, exposed at perhaps short range to artillery fire, without the support of their own artillery. Here is one of the most difficult problems for the commander of the artillery—to provide for the effective cannonade of the first position, to cover a check or repulse, and

at the same time to be forward for the second attack. Some batteries of the reserve may be pushed forward as much as possible with the infantry, taking all the advantage possible of cover, or if the greater part of the artillery has been engaged, those batteries which soonest cease to be useful must be sent forward. In any case, the operation is a difficult one. Probably mitrailleuses would be useful here. They have a terrific effect at short ranges, are light, and easily moved, and expose few horses to fire. A few mitrailleuses, crammed up with the infantry, might be at hand at once, and exercise a powerful effect in supporting their lodgment, and in preventing the retiring enemy from re-forming.

In the defence of a position, the part of the artillery must always be most important. The position of the guns must be carefully chosen, so that every inch of the ground over which the enemy can advance should be seen, and particularly that a strong fire should be concentrated on the roads and the ground on which it is probable the mass of the force will advance, whilst at the same time the guns must be protected, if possible, by the natural formation of the ground, but where this is not practicable, by vigorous use of the spade—the "demoralising spade" as it has been called, but here at least there can be no ill effects from its use. Whilst occupying all the points from which direct fire can be obtained, it is equally, or even more, necessary to take advantage of the flank fire that can be obtained. A position is like a fortress, and can only be effectively defended by seeing the whole ground in front. To follow the analogy, it is essential that positions in front of the main line in the nature of outworks should be strongly occupied, and held with firmness, to make the enemy develop his attack, and prevent anything in the nature of a surprise. Last autumn, if some points had been held in front of Fox Hills, if even the knoll behind which the Household Cavalry and the 42nd were to be seen had been occupied, would it have been possible for General Lyson's Brigade to break in upon the position with such disastrous effect? A strong position in itself may often be very weak, if held only in one main line. If forced at one point, which may well happen by the good tactics of the opposing general, all may be lost.

No defence can be thoroughly efficient without taking advantage of opportunities of counter attack. For this purpose it will be convenient to have the horse artillery on the flanks, to manœuvre on the flanks of the advancing enemy. Occasion may offer of firing on him when massing for attack behind ground which secures him from direct fire. If the horse artillery, and indeed all artillery not required in the main front, is disposed on the flank in echelon, it is not only powerful for counter attack, but ready also to meet and counteract the flank attacks of the enemy, to which it is almost certain he will resort.

I have laid great stress on these artillery attacks and counter attacks, because, in my humble judgment, it is the direction in which the full advantage of modern artillery is to be sought.

I know that high authorities advocate the employment of artillery in masses—amongst others the author I have already mentioned, the Prince of Hohenlohe-Ingelfingen, who himself (at the attack of St. Privat, I believe), massed 84 guns with distinguished success; and I will add that, from all I have heard, the tendency amongst the higher Prussian artillery officers during the late war was to mass their batteries. It would be most unbecoming in me to announce any *ex cathedrâ* opinion; but having been led to hold different views, let me simply give my reasons, and you can judge what they are worth.

First, although the Prussian artillery showed marked improvement since 1866, and although a general impression exists that it was very perfect, I think most Prussian officers would say that there was still plenty of room for improvement in its tactical performances. Witness the able pamphlet "Die Schäden der Organisation der Preussichen Artillerie."

Next, something must be allowed for the natural tendency of artillery commanding officers to wish to keep large masses under their own hands. The mere fact of having brought a large number of guns into action has something sensational about it; it strikes the imagination, and is sure to be remembered. The recorded facts of artillery in the wars of Napoleon are chiefly concentrations of large numbers of guns, and it is even yet hard to pass from the letter of his tactics.

I am far from saying that artillery should never be massed now, only that the occasions are much more rare, since guns can now work effectively over a far larger arc.

The evils of concentration are these:—The guns obtain only a direct fire on their object. They hamper the other arms, are less protected by them, and cannot support their attack so long, as a general rule, as when dispersed. Unless the country is very open, and practicable for all arms, the guns must either arrive unsupported, or be late in coming up. Prince Hohenlohe advocates the reserve artillery of a *corps d'armée* marching at the head of the main body of infantry, on the special ground that a mass of artillery can be utilised in action before the infantry comes up, for half an hour or more; and Captain Laymann takes much the same view. What if an attack upon this mass of guns should be pushed home by swarms of skirmishers? I believe the very case might have occurred to the artillery of the Crown Prince's army at Sedan. It was pushed forward early in the morning across the Meuse, towards Floing, and was long unsupported. Blumenthal was very uneasy about it, and perhaps if Ducrot had remained in command of the French, and carried out the retreat he wished, the blot might have been hit.

Lastly, masses of artillery, like cavalry, may be kept in hand for grand opportunities that never come.

What, then, are the modifications in artillery tactics to be looked for in the immediate future?

Extension of front and depth, both in attack and defence.

Dispersion of batteries, both for security, and more effective concentration of fire.

Employment of horse artillery on the greater radius, field batteries on the less.

Bolder action of guns on the flanks and rear in detached positions.

Large escorts with detached batteries handled as a separate tactical force.

Care to take advantage of shelter in moving.

Large intervals between guns when moving, and between limbers also in action.

The sacrifice of guns, if necessary, to secure the success of the main operation.

These are some of the principles by which we must guide ourselves in the future application of artillery. In what I have already said, I have tried to bring them into relief. It remains for me now to touch upon the more prominent faults which we see committed in the handling of the arm, to consider

how they can be avoided, and, finally, how the systematic tactical training can best be given, which is, I believe, the greatest want of our army at the present moment, not only in the handling of each arm to the best advantage, but in the higher and only real sense of tactics, the handling of the arms in combination.

And here I wish to say that any criticisms I offer are made in no dogmatical spirit. They will count only for what they are worth, you can judge them without the bias of any personal weight, and can readily form your own conclusions. The one thing I earnestly wish, is to excite interest and discussion on the subject. There can be no progress without discussion, but out of full and free discussion truth will finally prevail. I need hardly add that as I claim no personal authority, neither do I wish to claim any monopoly of tactical knowledge for artillery officers. To fail in technical artillery knowledge would indeed be disgraceful to us, but in the school of tactics we are all learners together; we are fully sensible that the faults committed in the field are often our own, we wish to study together how to avoid these faults, and, hand in hand, to advance the knowledge and power of the noble service to which we all belong.

Horse artillery is too much used with disregard of its special advantages. It is commonly sent a few hundred yards to the front to open fire at the commencement of an action. Thus it may be crippled early in the day for no corresponding advantage. A few moments are of no importance, and in every point of view field batteries are more effective in direct fire. It may, of course, be necessary to push horse artillery with cavalry some distance to the front, beyond the effective range of the guns with the main body. I only contend that horse artillery ought not to be used for direct fire when field batteries are available before the crisis of the action, nor ought it to be placed in position in the main line of defence without very cogent reason.

A French troop of horse artillery was *sacrificed* in this way in the Crimean war at the Tchernaya. It defended the Traktir Bridge at short range, and in a position where a field battery might have found better cover and fought with better effect.

In spite of the recent order of H.R.H. the Commander-in-Chief, artillery clings desperately to the other arms. The guns move more independently, but at the hottest time guns and infantry are pretty sure to be jammed up together. The field day I have already quoted is an instance—a brigade of infantry and several batteries jostling each other upon Long Hill. Surely the mass of artillery should have been upon the range behind, over the steeple-chase course, with some batteries of horse artillery on the slopes under Cæsar's Camp.

Again, in an attack on Cæsar's Camp and Beacon Hill from the north, little can be done by artillery in the plain in support of the direct attack of infantry, but is there not some field on either flank for detaching artillery, or rather a strong mixed force? The position is a very strong one against direct attack, but on the flanks and rear it is assailable, and is moreover an awkward one to retire from.

Again, in the attack on Fox Hills by General Carey, was there not scope for a free use of artillery considerably on the right of General Lysons' brigade, so as to gain the height and sweep the position in flank as soon as the mask should be thrown off? And for the cavalry and horse artillery of the

defence, or at all events part of it, was it not an error to retire before the brigade directly across the narrow plateau, and towards the remainder of the force? I believe an eccentric retreat towards the left, the guns remaining on General Lysons' right, would have done much more to check his advance, and have given more time to Sir C. Staveley to take up a second position. There would have been no more risk in this, I think, but in any case safety was not the first consideration. The whole brunt of the defence was thrown upon the troops at that point, and they were bound to sacrifice themselves to gain time.

Guns are generally too crowded, and positions taken up in a hurry. This, no doubt, arises from the anxiety to be doing something, and from the small space over which the guns are manœuvred. It would soon be corrected if the batteries were accustomed to a freer handling.

Guns should never be in the same line with infantry; mitrailleuses may probably find a place with them in the close attack of positions, but guns are hard to place effectively under infantry fire, and their fire is less effective at rifle ranges. Infantry would occupy the ground better.

This ought to be well understood, for nothing is a more common error in our manœuvres than the way in which skirmishers retiring retire at once *to* guns in action, instead of holding their ground in advance of the flanks. At the very moment guns are most useful in checking the enemy's advance, they are forced to retire because pressed by his skirmishers. And so it goes on; the guns retire, immediately the skirmishers retire again to them, and so on.

The artillery is, I think, hampered by an honourable tradition which attaches disgrace to the loss of a gun. This has been carried much too far. There would be indeed disgrace in the loss of guns through carelessness, or want of proper precaution, but none in the sacrifice of guns for a worthy object. Daring in attack, and persistency in defence will seldom be carried to the full extent to which they are capable whilst this opinion holds its ground to the extent it does.

Still more is this the case in manœuvres. Everything tends to make an officer inactive. Without excitement and hope of distinction to spur him on, he will be little inclined to lay himself open to blame for losing his guns, or to take it out of his horses by hard work. He sticks to old fashioned ways—to what is safe and sure. Rashness should be encouraged at field days, that we may learn what really may be safely undertaken and accomplished.

The real safety of our guns should be confided to the other arms. Artillery is powerful only for offence, and the cavalry and infantry should feel that it is their part to defend the guns with which they have a brotherhood in arms, as it is the part of the guns to support them to the uttermost. The shame in the loss of guns should be to the brigades and regiments with which they are placed, the shame to the gunners in allowing the other troops to be overwhelmed.

One fault that much prevents the success of our field days, is the little idea of the operations given to the officers holding subordinate commands. For instance, the officers commanding batteries are seldom told more than to take up a position on a certain hill, or to support a particular attack. They generally only know vaguely that the enemy is somewhere in their front. If he is imaginary, they seldom know what strength he is supposed to be, where he comes from, and on which point his retreat is likely to be, how far his position extends, on what point of the position the fire is to be directed, where

the attack is to be made, or on what position or by what road to retire, if retreat is ordered. If there is a real enemy, although some of these points may be plainer, others remain just as obscure, and in addition it is generally an open question whether the position of a battery is to be held obstinately, or yielded to comparatively slight prussure—whether, in fact, the position is of sufficient importance to incur serious loss for.

To go fully into this point would be to open a question with a most important bearing on tactics—the field organisation of artillery. This is evidently coming to the front. Our German friends are full of it, and *we* shall hear enough of it by and by. I only wish here to note that I have not forgotten it, but it is too weighty a subject to attempt to treat in the time at my disposal.

If, then, there are mistakes in the handling of troops committed in our manœuvres, how can they be remedied, and how can the necessary tactical instruction be best given at our camps and large centres? I believe that the greatest want of all, the missing link which is altogether dropped out of our system, is the handling of the three arms in small bodies, the careful training of men and officers in the minor operations of war, the march of small columns, advance and rear guards, the attack and defence of bridges, defiles, villages, detached farms, parts of a position. We devote the greatest attention to appearance and to drill, we polish and re-polish the unit until it is the marvel and admiration of beholders, and when we have got every part of the machine to a state of perfection, we seem to think that it will come by nature to put it together. Our autumn manœuvres, and indeed our large field days, are like trying to run before we can walk. They are on too large a scale for effective criticism, except as regards the strategical plan, or at all events the large tactical execution of it. The superior officers are too much occupied with the large features, and have no time to superintend details. Hence the same mistakes are made over and over again. Nothing is or can be criticised in detail. And so it must be until officers are taught to handle small bodies of troops as they are taught drill, and junior officers are accustomed to handle them against each other. When we take up this missing link, and only then, shall we be able to derive full profit from large manœuvres.

The combination of the arms is at present only possible at our camps, and a few of our large stations. Does it not seem that more might be done to train subordinate officers for command, and to implant in the minds of all ranks the definite principles on which they must act before the enemy? Amongst them must be found the future leaders of our troops; how are they to succeed in war unless they are trained in tactics as they are trained in drill and interior economy?

It is not thus that the Prussians have attained their marvellous success. They have not neglected the beginning; they have indeed built upon a thorough and minute knowledge of details, but they have known how to keep these details in their proper place and due proportion, and how to subordinate them all to the main end of progress and practice in the whole art of war. Yet they are not blinded by success. Even now, on the morrow of it, their most earnest writers are freely criticising. Everywhere the cry is "Excelsior!" Everywhere their success is looked upon as the point of a new departure. Why should not we borrow something of this spirit; not follow the lead of the Prussians because they have achieved the latest success, but work out the problems of the future for ourselves?

I am afraid we have sometimes rested content with the first stage, with the perfection of drill and equipment, in which we stand pre-eminent, and have thought that straight going and hard fighting will do the rest, or that, at all events, we shall pick up what we want after a licking or two. Well, is there time? Recent wars hardly encourage the idea; there is no royal road to success in war more than in anything else. I do not want anything we have yet reached to be relaxed. Let our drill and turn out be as carefully maintained as ever, but I plead for more opportunities of training in the field, beginning with training in small bodies that can be carefully supervised.

I believe that if instead of our somewhat desultory and uncertain method of drill, we carried out more strictly and thoroughly the annual system which exists theoretically, but is often disregarded in practice; if we thought more of the proper sequence of instruction, and gave each part of it entirely into the hands of the individual responsible for it; there would be a marked improvement in the tactical performances of the arms. Men learn more in a dozen consecutive drills, than in three times the number interspersed with other exercises. I think time is often lost now by a habit of looking at the year as a collection of weeks, instead of as a whole.

The preliminary drills, all that go to make up the efficiency of a regiment or battery in detail, should be steadily pursued, each one its allotted time, from October to the middle of March; then would follow the drill of the battery or regiment, including not only drill proper, but the handling of the unit under the conditions of service; then the brigade drills; after this the troops would be ready to be put together for minor manœuvres, and finally for grand manœuvres. The time within which each branch of instruction would have to be given, would of course depend on the station, and whether the combined manœuvres could be practised at all.

I hope that it will soon be found possible in every military district to bring together small bodies of all arms, for a short time in each summer, irrespective of the larger manœuvres. But whether this can be done or not, all I am now anxious to note is that the principle of consecutive instruction should be rigidly maintained as an economy of time, which is more and more important as short service becomes the rule.

Finally, there is one very real hindrance to the development of tactics; and that is the jealousy, or rather, perhaps, want of interest in each other, between the different arms, and not only between those with which I have now been immediately concerned, but amongst all branches of the service. Our admirable regimental system, amongst its many and undeniable merits, has one defect. It has fostered a selfish and narrow spirit, which can see no good thing outside its own circle. This is the old spirit of the guild, and there can be no progress till it is utterly thrown away. The true *esprit de corps*, whilst neglecting nothing that tends to the perfection of its own corps, and guarding its honour and reputation with the utmost jealousy, will not remain content in selfish isolation, but will reach on to the wider brotherhood in arms, which indeed springs into life in the stern atmosphere of war, but is too little sought in the piping times of peace.

One word in conclusion. I know there is an impression abroad that only those who are masters in the lecture room should appear here. It appears to me that this is entirely to misapprehend the use and object of these lectures. Speaking for myself alone, I have no pretension to teach such an audience as

this, and nothing was further from my thoughts when I first consented to come here. It was, I believe, to create and foster an interest in professional subjects amongst a larger number of officers, to stimulate discussion which might bear fruit in practical improvement, that these meetings were first started. It is, then, only right and proper that those serving in the command should come forward to do what they can, and it would be out of place for able and well known men to come from outside to lecture on abstract subjects. The lecture room here should be in close connection with the practice ground.

I wish that these meetings were sometimes followed by discussion; but, at all events, if they ever strike a note in the mind of any present, they do not entirely fail of their object.

The negative criticism which condemns them for not being better, and equally condemns the training in the field, which it will not take the trouble to try to improve, is an enemy to knowledge and to progress. But the immensely increased interest shown on all sides in professional subjects, shows that there is power working that must bear fruit in the future. Everywhere new ideas are taking root, everywhere we are recognising that knowledge is power, and we must not forget, what we are somewhat slow to grasp firmly, that union is strength.

ALDERSHOT,

March 27, 1872.

100. GERMAN $8\frac{1}{2}$-IN. GUN.

(Communicated by Lieut.-Colonel W. E. M. Reilly, C.B., R.A.)

Construction.—This gun of $8\frac{1}{2}$-in. calibre is a breech-loader, having its breech closed by a wedge, in the centre of which is the vent, nearly in prolongation of the axis of the bore. It is of cast steel, and consists of an inner tube surrounded by nine cast steel hoops, shrunk on. The inner tube is the full length of the gun, 15 ft. $8\frac{1}{2}$ ins., and may be considered of three thicknesses:—First, that about the loading-chamber and vent-piece, where there are no hoops. The next portion is cylindrical and rather thinner, and reaches to about half the length of the gun. This is belted by one layer of five hoops, the rear one of which is very narrow, the front ring being broad, and being also the trunnion ring. Round this layer, and over the powder-chamber, is a second layer of one broad hoop. The third portion of the tube, extending to the muzzle, is conical, and has three narrower hoops forming on the exterior surface steps adjoining the five hoops above-mentioned. At this junction is a ring, half in the tube and half in the hoops, which prevents the tube breaking away to the rear from the system of hoops.

Weight.—The weight of the gun is 9 tons, including vent-piece, which weighs $7\frac{1}{2}$ cwt.

The axis of the trunnions passes through the axis of the bore.

There is no preponderance.

The rifling consists of thirty grooves, whose driving edges have a twist of 1 in 38 calibres, or $2° 38' 42{\cdot}6''$.

Breech Ring.—At the end of the bore is a breech ring, which is set in an enlargement of the rear edge of the loading-chamber. This ring is hollowed out to the front, so that the action of the gas merely presses it tighter against the enlargement in which it is set.

Wedge.—The wedge is also of cast steel, is very slightly tapered, and enters its chamber from the left. In shape it is cylindro-prismatic, its front being a plane, its rear semicircular in section. Its motion is effected with great facility by means of a screw working in two collar blocks, one at either end of the wedge, which may be termed the carrying screw. This screw works against a half female screw in the top of the wedge-chamber. The screw is worked by a wrench. On the front of the wedge is a circular steel plate of slightly larger dimensions than the height of the wedge. This is hollowed out towards the front, and pierced through the centre for the vent; but as it is necessary to preserve contact between this plate and the breech ring, it can be advanced by placing a thin brass plate beneath it.

In order to press the face of the wedge firmly against the breech ring, there is in a slot in the rear part of the wedge a screw, on which works a collar having three teeth on one side of its exterior. When the wedge is home, by a half turn to the right, this screw carries the collar round with it, so that its teeth fall into corresponding slots in the side of the wedge-chamber. By continuing the operation of screwing, the screw works in the collar (which is now fixed), and thus forces the wedge further home, and at the same time its face against the breech ring. On the

end of the wedge a ring handle is provided, to be used in the event of the "carrying screw" getting out of order. A chain attached to the wedge, and also to the gun, regulates the distance to which the former can be withdrawn.

The wrench is 20 ins. long, and available both for the "carrying screw" and also for the "wedge screw." The wedge can be worked by one or two men, but in the event of this power being insufficient, a piece of cast-iron gas-piping is put on the wrench to increase the leverage.

Loading-Box.—The withdrawal of the wedge admits of the insertion of a "loading-box" through the end of the breech, the front end touching the breech ring, the rear end being rounded off. It is a tube of cast steel, and is kept in its proper position during loading by two latches, which turn on pivots in the breech and "catch" against two bearer pins. It is probable that a "shell" or half-cylinder will be introduced to supersede this "box," which will have the advantage of being lighter.

Vent-Bush.—The vent-bush passes through the wedge in prolongation of the axis of the bore, when the breech is closed, to avoid weakening the gun. It is of steel, having a copper ring in front of it; this ring can be renewed when worn out.

The bush is somewhat thicker in its front part than elsewhere, to secure its position; its rear end is closed by a piece of metal working in a concavity in the breech-piece, on a pivot. This has a slot cut in it to take the friction bar of the tube when placed in the vent.

Sights.—The gun is provided with two fore-sights and tangent scales, the latter graduated in degrees up to 15°.

Projectiles.—The projectiles provided for this gun are chilled and common shells, $2\frac{1}{2}$ calibres = 20 ins., the head being 1·3.

Chilled Shell.—1·3 of a calibre, the rounding of which is obtained by a circle whose radius equals twice the diameter of the shell without the lead coating. Its bursting charge is 2·42 lbs., and the length of the hollow is limited so as to leave the whole of the head solid. The base is closed as in the British service, with the exception that the plug is provided with a ring by which the shell is hooked to the tackle in raising it. For moving the shell a short rope is provided, having a hook at one end and an eye at the other. There is a loop in the rope which is passed over the point of the shell when the hook is attached to the base ring.

Common Shell.—The common shell has also a length of $2\frac{1}{2}$ calibres, of which one is that of the head. There are two extractor holes in the head, to enable it to be lifted by means of a clip.

The burster is 11 lbs.

For facility of fabrication, a hole is made in the base, which is filled up by a left-handed screw plug.

Cartridge.—The cartridge, $37\frac{1}{2}$ lbs., contains $23\frac{1}{2}$ layers of hexagonal prisms, 19 in each layer, or 447 prisms, and is 24·2 ins. in length. The material of the cartridge is silk. The 31-lb. cartridge has 368 prisms, and is 20 ins. in length.

The cartridges have, therefore, hexagonal form, with the edges rounded off.

Friction Tube.—The friction tube is of quill, at the open end of which is choked in a short piece of quill containing the detonating composition and a wooden plug, through which passes a brass friction, its outer end terminating in a ring, its inner end being turned back.

The Lanyard.—The lanyard has two branches, one end in a loop which is laid over the tangent scale; and thus during the service of the gun the lanyard is permanently attached. The other branch, which has the hook at its extremity, is provided with a loop which is hooked on to the bearer pin or hook, and thus provides a similar arrangement as in the British naval service.

Rapidity of Fire.—It is considered that this gun can be properly laid and fired at the rate of one round per minute.

Penetration.—No data are given as to range or elevation, and little as regards penetration, but it is calculated that the chilled shell will penetrate at 500 yds. a target having 8 ins. of iron, with teak backing of 10 ins. thickness, and double inner skins, each of ¾-in. iron.

Loading.—After loading, the loading-box must be withdrawn, to allow the wedge to be screwed home. The withdrawal of the wedge and clearing the vent are performed during the running up of the gun.

The Gun.

Breech or muzzle-loading	B.L.	Weight of piece ....cwts.	180, 15·81lb. including vent-piece.
Calibre ....ins.	8·44	Material and method of construction	Cast steel.
Grooves, number	30	System of breech-loading	Wedge.
Pitch of rifling	2°38′42·6″, or 1 in 68 cals. for driving edge.	Initial velocity with battering or highest charge ......ft. per sec.	1284·56 for hardened shell.
Length ... over all ....ins.	188·64	Rapidity of fire	1 round per minute.
Length ... of bore .... „	162		
Length ... of rifling ...... „	126·38		
Breech preponderance........lbs.	0		

Ammunition.

Com. shell — diameter ......ins.	8·44 / 8·11	Battering shell or shot — length ....ins.	20·59
Com. shell — length .... „	20·59	Battering shell or shot — weight, filled...lbs.	277·15
Com. shell — weight, filled...lbs.	174·16	Battering shell or shot — bursting charge „	2·42
Com. shell — bursting charge „	11	Battering or highest charge of powder .... „	37·48
Battering shell or shot — material	Chilled iron.	Service or ordinary, do. ...... „	30·86
Battering shell or shot — diameter ......ins.	8·44 / 8·1		

101. ACCOUNT OF THE BURSTING OF AN 11-IN. CAST STEEL KRUPP GUN, AT CRONSTADT, ON SEPT. 29, 1871. Extracted from the "Archiv für die Artillerie und Ingenieur Offiziere des deutschen Reichsheeres." Berlin, 1872.

(Communicated by Lieut. F. E. B. Loraine, R.H.A.)

An article which lately appeared in the Russian "Invalides," and was from thence transferred to the "Militair Wochenblatt," relative to the bursting of an 11-in. Krupp gun at Cronstadt, on October 11, 1871, is worthy of notice. As, however, the explanation of the mishap which is there attempted contains so much that is unintelligible, and, as far as it is intelligible, admits of serious question, we purpose, before placing it before our readers, to offer the following sketch of the attendant circumstances.

The front conical part of the gun burst as far as the front strengthening ring on the first occasion of being fired with a charge of 90 lbs. of prismatic powder and a double shell weighing 495 lbs., after two rounds had already been fired with 64 lbs. of prismatic powder. The cone broke into two parts, the line of breakage being nearly perpendicular to the axis of the piece; the rear and shorter part (about a third of the length of the cone) was itself separated into two smaller pieces by a longitudinal fracture. The front part was burst into four larger pieces. The broken surface of the body of the gun ran irregularly, partly under the ring, partly outside it, and the bursting took place (probably) when the base of the shell was from two to three feet from the muzzle of the gun. The gases which streamed out of the broken part of the gun to the rear knocked down part of the gun detachment, without, however, injuring anyone. Some of the fragments which flew to the rear conformed precisely to the direction imparted to the gun on recoil; others fell straight to the ground. Of those which flew to the front, two fragments ricochetted several times on the ground, and eventually settled in the sea, at a distance of about 33 yds. from the gun, conforming in their flight to the direction of the projectile. One of the latter fragments has already been recovered. A larger fragment, which was broken off close to the strengthening ring, still lies in the sea.

To judge from the appearance of the broken surface, the steel was faultless, so no blame can be attributable to it; and by means of several impressions of the lands and grooves taken at the place where, from the surface of the fracture, we may infer that the breakage began, the probable conclusion has been arrived at that the shell was jammed in the bore. Precisely the same arrangements were made for loading with the double shell as with shot of ordinary length, so that the powder chamber was shortened by about 2·3 in., and the pressure on the shell and the bore consequently increased. In addition to this, some of the other double shells which were experimented with displayed a very porous surface.

At the manufactory the following rounds were fired out of the gun—viz., one with 66, one with 77, and four with 88 lbs. of prismatic powder, and in each case a full sized projectile weighing 517 lbs.

We now proceed to quote the article extracted by the "Militair Wochenblatt," from the Russian "Invalides":—

"The chase or unstrengthened part of the gun burst on the first occasion that it was subjected to a charge of 100 lbs. (Russ.) of prismatic powder, and a projectile

weighing 550 lbs. (Russ.), a special committee having been appointed to superintend the experiment.

"The bursting was not caused by the jamming of the shot, as the lands and grooves were everywhere quite uninjured (?),* but in the opinion of the committee it was probably due to a flaw in the metal near the muzzle; and this opinion was founded on the general direction of the fracture, on the appearance of the metal at the fracture, and on the position of the fragments torn from the gun. The most characteristic circumstance was the tearing off of some of the fragments close to the muzzle, where on one of the surfaces of breakage a fibrous expansion of the metal was not observable, while it was to be found on all the others. Such a crack, however, entirely without indentations, notches, or crumbled bits, is peculiar to metal which has been burst at a spot where there had previously been a flaw (?).

"Experience teaches us that such flaws originate at the boring of guns out of cast (and not wrought) metal, on the surface of which hollow spots are discernible. Experience has equally taught us that such flaws are only to be found in the chase of a gun—never in the chamber. When the gun is bored out, most of these flaws disappear, but they are sometimes so fine that the eye cannot detect them, and when they remain on the surface of the bore they may cause the bursting of the gun. However, this but rarely happens, and the writer knows but of one case in which it has happened.

"At Slatrusk a star-shaped flaw was discovered in a 4-pr. steel gun, after it had been bored out. When the gun was further bored out the flaw disappeared, but a very careful examination revealed traces of it, as fine as hair, at the muzzle of the gun (were these traces offshoots from the star-shaped flaw ?). This gun was then subjected to the most careful experiments, and at the 813th round the muzzle was torn off, and the fracture was found to be in the same direction as the above-mentioned flaw (?).

"This was analogous to the bursting of the 11-in. gun, with this difference—that in the one case the previously existing flaw was pointed out, in the other it was not. The largeness of the charge had nothing to do with the matter, but the sole origin of the mischief was a pre-existent flaw in the bore of the gun. Flaws are often to be found in cast-iron and bronze guns, without necessarily causing them to burst. They can never be quite avoided. The expansion of the powder gas at the muzzle of an 11-in. gun is as nothing against the resisting power of steel tubes of such a calibre. It is therefore highly probable that the bursting of the gun in question was caused by a flaw near the muzzle."

However we may be disposed to examine the explanation here attempted, we must necessarily come to the conclusion that it cannot hold water for one moment, since no one could *really point out* in the fragments that were picked up the flaw near the muzzle ascribed to the gun. The proof of such a flaw should be demanded, because every crack produced by the force of powder, or in any violent way whatever, shows a crystalline or fibrous structure of the metal, which is not the case with cracks, whether in the shape of holes or fissures, which are produced during the founding of the metal, and the difference between the two is such that it can be plainly recognised even by the eye of the uninitiated. But, as regards the circumstance from which it has been inferred that one may assume the existence of a fault in the metal arising during manufacture from the fact that one crack displayed no

* The notes of interrogation are in every case those of the writer in the "Archiv."

fibrous structure while the others did, it is well known that this fibrous structure tends to disappear, and to give place to a clean, smooth, crystalline surface, in proportion to the suddenness with which the bursting of the metal takes place. Now, the beginning of every bursting of a gun naturally lasts a shorter time than the end of it, and so different structures will continually be recognised in cracks which have not been quite simultaneously produced, provided the excellence and homogeneity of the metal of the gun leave nothing to be desired.

Whether the cause which made the 11-in. Krupp gun burst at the muzzle will receive a completely satisfactory clearing up may be left undecided. Meanwhile we may rest satisfied that the present is an exceptional case, and to anticipate all exceptional cases we may characterise as an impossibility. In any case it would be easy at once to make the muzzle ends of rifled guns stronger than is customary, or even to strengthen them not immaterially by the addition of a reinforce ring and ojee; but even this arrangement would not obviate the possibility* of a gun thus strengthened occasionally splitting at the muzzle.

And here let us call to our recollection the Lancaster guns which were brought into use in the Crimean war, and subsequently abolished. These guns had smooth elliptical bores, with an increasing twist. Their elongated projectiles were made to fit the bore, in which they received the same rotatory motion round their longer axes as the projectiles of rifled guns. As the Lancaster guns were muzzle-loaders, and had therefore windage, a jamming of the projectile occasionally took place, the result of which was either the breaking up of the same, or the splitting of the chase of the gun. The construction of these guns was therefore a failure.

If any dirt, or indeed any foreign matter, be collected in the chase of our present rifled guns, the projectile will not take time, on the discharge of the gun, to force it out, but will force its own way over it. Then if the lead coating cannot find sufficient room, the natural result is either the splitting of the steel tube or the smashing of the projectile.

At experiments which were made with smooth-bore muskets more than thirty years ago, merely for the purpose of clearing up this matter, barrels which had previously been stopped with sand or dirt were almost invariably split at the muzzle by the round lead bullets which were fired out of them.

Again, with reference to the position of the fragments of the 11-in. gun, we may remark that when on the bursting of a gun parts of the same fly in a forward direction, such can only have been effected by means of the shot impelled by the explosive force of the charge. Also, the mere falling of some of the fragments in a downward direction, and the fact that some of those fragments were not also hurled sideways by the force of the powder, may, if not with certainty, at least with great probability, lead to the final conclusion that the chase of the gun was certainly not burst, but simply split by a jamming of the projectile in the bore, although this might also have been accompanied by a sideward motion of the fragments.

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* The German word is "Unmöglichkeit," which must either be a printer's error, or a result of the very obscure, involved style which characterises the writer in the "Archiv."

A FEW HINTS UPON COLLECTING OBJECTS

OF

NATURAL HISTORY.

BY

MR. H. WHITELY,

CURATOR OF THE MUSEUM, ROYAL ARTILLERY INSTITUTION, WOOLWICH.

DOUBTLESS there are many members of the Institution who would gladly contribute to the collection of Natural History, did they but know what to collect, and how to preserve the specimens when collected. The following brief remarks are published with the view of assisting the student, and to facilitate the classification.

Commencing with mammals:—Skulls of all the larger species would be of great interest, want of space making it undesirable that the skin of the whole animal should be sent; the smaller species—such as bats, rats, mice, moles, &c.—may be either skinned or preserved entire in large bottles, or small wooden kegs; any kind of spirits* will do to preserve them in, and if of ordinary strength may be diluted with one-fifth of water, unless it is necessary to crowd the specimens; when such is the case, the water must be omitted.

It will add greatly to the perfect preservation of the specimens during transportation, if each one is wrapped up in cloth or paper. In packing, place all the larger specimens at the bottom, and if there are any very delicate ones, they must be separated by means of some immovable partition to prevent any damage being done to them in case the vessel should be inverted; great care must also be taken, before the final closing of the vessel, that it is perfectly full.

All specimens should have an incision made in the abdomen to admit the spirits; if several of a kind are preserved, the intestines of some may be entirely removed to insure their perfect preservation.

The best plan of capturing the smaller animals, such as rats, mice, &c., is by means of the common rat and mouse traps; those caught alive in traps will be found the best. The traps can be baited with fish, corn, fruit; toasted cheese will always be found a most attractive bait. By this means many animals will be taken that were previously unknown in the locality; for many of them being nocturnal in their habits may have escaped observation.

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* It is advisable to add a little tartar emetic, as cases have arrived at the Institution from which the spirits had been abstracted, and consequently the specimens were completely destroyed.

Fine sand smoothly laid in open spaces in woods, or in tracks leading to or from ponds or streams, will often indicate by the impressions left behind that there are those in the neighbourhood that you would be pleased to become better acquainted with.

The larger mammals in most cases can be obtained by placing strychnine on any bait laid for them.

Skulls may be preserved by boiling, or cutting away the muscle and drying, or by putting in spirits; but in every case care should be taken not to cut or mutilate the bone.

In the case of antelopes and deer, when not convenient to take the whole skull, sufficient should be taken to keep the horns attached.

When the skin of any of the larger mammals is to be preserved, the following mixture may be used: alum two parts, saltpetre one, to be pounded into a fine powder and well mixed; at the same time it must be stated that arsenic is the only true curative agent, all others only answer for a short time. Every portion of the skin must be covered while in a fresh state; the skin may then be allowed to dry partially, and when folded up, the hair side should be placed outwards.

Birds.

In making collections of birds, the following notes should be taken:—

Length from tip of bill to the end of tail, expanse of outstretched wings, length of wing from the carpal or first joint. If put down in this manner—20, 36, 10 (the figures representing inches), the first will stand for the length; the second, the outstretched wings; the third, length of wing from first joint. The colour of the eyes, feet, bill, or any other naked part; the sex, which should always be given from dissection; the date and locality. If the specimen is numbered and a note-book kept, the whole of these remarks should be recorded against the number in the book; when no book is kept, they should be written upon a label and attached to the bird.

For preserving the skins of birds there is nothing equal to arsenical soap, which may be made in the following manner:—

Camphor, 5 ozs.; powdered arsenic, 2 lbs.; white soap, 2 lbs.; salt of tartar, 12 ozs.; powdered chalk, 4 ozs. Cut the soap into small slices, as thin as possible, put them into a pot over a gentle fire, with a very little water, stirring it often with a wooden spoon; when dissolved, add the salts of tartar and powdered chalk; take it off the fire, add the arsenic, and stir the whole gently; lastly, put in the camphor, which must first be pounded in a mortar with a little spirits of wine. When the whole is properly mixed together, it will have the consistence of paste. It may be preserved in tin or earthenware pots, well closed and cautiously labelled. When wanted for use, it must be diluted with a little cold water to the consistence of clear broth; the pot may be covered with a lid of pasteboard, having a hole for the passage of the brush by which the liquor is applied. This mixture must be applied to all parts of the inner surface of the skin.

Plaster of Paris, powdered chalk, or whiting will be found of much use in skinning specimens that are very fat or bloody, by being applied to the inside of the skin, as they quickly absorb the grease and blood.

Specimens of birds from all parts of the world are much wanted for

the collection of skins to be arranged in cabinets; no matter how common or plain in plumage a bird may be, it should be preserved; for although common in one locality, it may be very rare in others.

Fish and Reptiles.

All the smaller ones are best preserved in spirits, following the directions under the head of mammals. The larger ones should be skinned, and if convenient, then placed in spirits; when that cannot be done, they should be well dried and packed in boxes, occasionally giving them a sprinkling with spirits of turpentine.

Insects.

In this branch the Institution collection is very deficient; donations from all parts of the world will be thankfully received. Beetles will give but little trouble in collecting or preserving; the best plan is to put them in wide-mouthed bottles with spirits, not crowding the bottles too much. They may be sought for in damp places—under stones, in the bark of trees, dung, the bodies of dead animals, and in stagnant water.

Butterflies, bees, wasps, &c., if packed in layers of soft paper, or cotton, will travel quite safely. As the setting of these is attended with some trouble, and cannot be always done at the time of capture, it is as well to know that they can be relaxed and properly set upon their arrival in this country.

Shells, Coral, &c.

Any from Australia or New Zealand will be of value to the Institution collection. Land shells from all quarters will be of much interest.

Birds' eggs, if well authenticated, would be highly prized; but if there should be any doubt on this point, they are of little value.

THE FOLLOWING NOTES ON THIS SUBJECT HAVE BEEN KINDLY FURNISHED BY MR. J. K. LORD, F.Z.S.

Birds.

An efficacious mode of preserving their skins is by means of a piece of common yellow soap and arsenic in powder.

Work up a lather first, just as for shaving, with a sash-tool, dip the brush covered with lather into the arsenic, and well rub it into the skin. The camphor is best sewn up in the skin in small pieces.

A solution of bi-chloride of mercury should always be kept for washing over bill, feet, and rump.

Insects.

In collecting insects, a wide-mouthed bottle fitted with a *bung* stopper, tied over or rather covered with thin leather, should always be carried, the leather being tied at the top to form a knob, to aid in pulling out the stopper. Fastened to this bung by a bit of fine wire is a small sponge

(the wire should reach within two inches of the bottom of the bottle); this sponge should be kept wet with chloroform, which may be carried in a small stoppered phial in the pocket. Every insect caught, of whatever order, should be at once popped into this bottle, which will cause its instant death. This will be found a capital plan, as violent struggling damages the fine colouring of a great many insects. Beetles can always be packed between layers of rags.

Butterflies, pressed flat and packed in triangular pieces of paper tightly gummed up, travel admirably.

Shells.

In collecting univalve marine shells, the fish may be boiled out, but great care should always be taken to *carefully* preserve the operculum. After cleaning out the fish, the shell should be filled with dry cotton wool (animal wool should in all cases be carefully avoided), and the operculum stuck to the wool at the mouth of the shell.

Small crabs may be easily preserved by soaking them well in cold *fresh water* for eight or ten hours; when thoroughly dried, wash them over with the solution of bi-chloride of mercury.

Large specimens should be cleaned out, and then rearticulated.

LIST OF SPECIMENS WANTED FROM VARIOUS STATIONS FOR THE MUSEUM OF THE ROYAL ARTILLERY INSTITUTION, WOOLWICH.

Gibraltar.

Birds, butterflies, beetles, bees and wasps, reptiles, and what land shells are to be found.

Malta.

Birds, butterflies, beetles, dragon flies, crickets, locusts, small specimens of fish in spirits, and land and marine shells.

Bermuda.

Shells, coral, and sponges.

Mauritius.

Birds, insects of all orders, crabs, crawfish, marine, fresh water, and land shells; also sponges, and small specimens of coral.

Ceylon.

Birds, butterflies, beetles, in particular; also marine, fresh water, and land shells.

St. Helena.

Same as above.

Aden.

Shells, small specimens of coral, sponges, crabs, crawfish, and also small specimens of fish in spirits; likewise birds, butterflies, and beetles. The beetles travel well in bottles packed in sawdust, slightly moistened with weak carbolic acid.

East Indies.

Birds, butterflies, beetles, bees, wasps, dragon flies, locusts, mantis, small fresh water fish from the mountain streams, in spirits; also land and fresh water shells. A complete collection of the game birds found at the different stations would be of great interest.

Singapore, Hong Kong, Shanghai, and Penang.

Birds, beetles, butterflies, wasps, bees, locusts, mantis, dragon flies, ants, crabs, crawfish, marine, fresh water, and land shells.

South Africa.

Birds, insects of all orders, the smaller species of reptiles in spirits, land, fresh water, and marine shells.

Australia and New Zealand.

Birds of all orders, from New Zealand in particular, the two owl parrots (strigops habroptilus and Greyii), and the three apteryx (apteryx australis, mantellii, and oweni); also butterflies, beetles, mantis, dragon flies, land, fresh water, and marine shells; also specimens of the smaller fresh water fish in spirits.

Japan.

Birds and insects of all orders, shells, corals, crabs, and sponges.

North America and West Indies.

Birds, butterflies, moths, beetles, small reptiles in spirits, land and fresh water shells, and the eggs of any of the water fowl that breed round the coast.

List of War Office Photographs received during the year 1871–2.

		s.	d.
Demy pictures, mounted	....	2	6
" " unmounted	....	2	0
Quarto " mounted	....	1	8
" " unmounted	....	1	4

3192 General view of No. 31 War Office shield and casemate, before practice. July 1, 1870.

3193 Front of do. After round No. 1744, Palliser cored shot, from 12-inch M.L. rifled gun. Charge 73½ lbs. pellet powder. Range 30 yds. Angle of incidence 30°. July 1, 1870.

3194 Front of do. After round No. 1745, Palliser live shell, from 12-inch M.L. rifled gun. Charge 73½ lbs. pellet powder. Range 30 yds. Angle of incidence 30°. July 1, 1870.

3195 General view of do. After practice. July 1, 1870.

3196 Front of do. After round 1746 from 15-inch Rodman cast-iron gun. Charge 83¼ lbs. L.G.R. powder. Range 200 yds. July 5, 1870.

3197 Front of do. do. After round 1747 do. do.

3198 do. do. 1748 do. do.

3199 do. do. 1749 do. do.

3200 do. do. 1750 do. do.

3201 do. do. 1751 do. do.

3202 Back of right side of port of No. 31 War Office shield. July 5, 1871.

3203 Large Gatling gun.

3204 do. Front view.

3205 Small Gatling gun. Rear view.

3206 Small Gatling gun.

3207 Front of 8-inch portion of No. 30 target, after rounds Nos. 1752 to 1758 from 9-inch M.L. rifled gun. Charge 43 lbs. Range 70 yds. July 6, 1870.

3208 Front of Chalmers' portion of No. 30 target, after rounds Nos. 1759 to 1761 from 7-inch M.L. rifled gun. Charge 9 lbs. Range 70 yds. July 6, 1870.

3209 Front of 8-inch portion of No. 30 target, after rounds Nos. 1762 to 1765 from 7-inch M.L. rifled gun. Charge 22 lbs. Range 70 yds. July 7, 1870.

3210 Front of experimental port frame, after round No. 1766 from 12-inch M.L. rifled gun. Charge 73½ lbs. pellet powder. Range 30 yds.

3211 Front of back plate, front plate thrown down.

3212 do. Port frame placed in position.

3213 Back of front plate.

3219 Front of 8-inch portion of No. 30 target, after 8 rounds, Palliser's projectiles, from 9-inch M.L. rifled gun. Charges—Nos. 1767 to 1770, 14 lbs.; Nos. 1771 to 1774, 43 lbs. Range 70 yds. August 1, 1870.

3220 Site of the bursting of 68-pr. C.I. gun, converted on Major Palliser's system. August 10, 1870.
3221 Wooden target 9′ × 9′ × 2″, having outlines of 3 cavalry and 5 infantry men chalked on it, for experiments of Mitrailleuse Committee.
3222 134 dummies, placed in loose order on uneven ground, representing broken infantry retiring.
3223 Portion of Moncrieff carriage for 7-inch 7-ton gun, showing damage caused by accident while "running up." August 19, 1870.
3262 Moncrieff carriage for 9-inch M.L. rifled gun, ready for firing. Weight of gun, 12 tons, 11 cwt., 2 qrs.; do. of carriage, 2 tons, 12 cwt., 1 qr.; do. of elevator, with ballast, 23 tons, 15 cwt., 1 qr.; do. of platform, 9 tons, 1 cwt.
3263 Moncrieff carriage for 9-inch M.L. rifled gun, ready for loading. Weight as above.
3264 9-inch M.L. rifled howitzer, Expl. No. 370, mounted on a wrought-iron sliding carriage and wood dwarf traversing platform, fitted with hydraulic buffer, and rack traversing arrangement. Weight of howitzer, 5 tons, 11 cwt., 2 qrs., 23 lbs.; preponderance, 2 cwt. 2 qrs.; weight of carriage, 2 tons, 0 qrs., 2 lbs.; do. of platform, 3 tons, 1 qr.
3265 Front of portion of target representing Plymouth Breakwater Fort, after two rounds from 12-inch M.L. rifled gun—No. 1778, Palliser shell, charge 67 lbs.; No. 1779, Palliser shot, charge 23½ lbs. Range 20 yds. October 26, 1870.
3266 General view of target representing Plymouth Breakwater Fort, showing extra 5-inch plate knocked away.
3267 Front of portion of No. 29 target, after two rounds from 9-inch M.L.R. gun —No. 1780, service Palliser shot; No. 1781, experimental shot, made of Swedish iron, from Finspong. Charge 15 lbs. Range 20 yds. Oct. 26, 1870.
3308 Front of target representing Plymouth Breakwater Fort, after five rounds (1782 to 1786) from 9-inch M.L. rifled gun. Charge 43 lbs. Range 30 yds. December 8, 1870.
3309 Back of do. After practice. December 8, 1870.
3310 Front of do. After five rounds (Nos. 1787 to 1791) from 10-inch M.L. rifled gun. Charge 30 lbs. Range 40 yds.
3311 Back of do. After practice. December 15, 1870.
3416 12-inch M.L.R. gun of 35 tons (700-pr.), constructed in the Royal Gun Factories.
3417 do. do.
3418 9-pr. M.L. rifled wrought-iron gun of 8 cwt., with W.I. carriage and limber.
3419 do. do.
3420 do. do., unlimbered.
3421 do. do. do.
3724 7-inch B.L. gun, mounted on Moncrieff carriage and slide. Loading position.
3725 do. do. Firing position.
3726 Royal Horse Artillery, in marching order.
3727 Infantry ammunition cart.
3728 do. do.
3729 Battery mounted for experiment against Admiralty turret target, 10-inch, 11-inch, and 12-inch M.L.R. guns.
3730 Front of Admiralty turret target No. 34. Before practice.
3731 Back of do.
3732 Front of Admiralty turret target No. 35. Before practice.
3733 Back of do.

3734 Front of Admiralty turret target No. 34, after round No. 1792 from 12-inch M.L.R. gun. Charge 85 lbs. P. powder. Range 200 yds. May 4, 1871.
3735 Front of do. No. 35, after round No. 1793, do.
3736 do. No. 34, do. No. 1794, do.
3737 do. No. 35, do. No. 1795, do.
3738 do. No. 35, after rounds Nos. 1799 and 1800, do.
3739 do. No. 35, after round No. 1802 from 11-inch M.L.R. gun. Charge 85 lbs. P. powder. Range 200 yds. May 5, 1871.
3740 do. No. 34, after round No. 1803, do.
3741 do. do. do. No. 1804, do.
3742 do. do. after rounds Nos. 1808 and 1809, do.
3743 do. No. 35, after round No. 1810, do.
3744 do. do. do. No. 1812, from 10-inch M.L.R. gun. Charge 70 lbs. P. powder. Range 200 yds. May 8, 1871.
3745 Pieces of Palliser shot fired at Admiralty turret target No. 34—No. 1792, 12-inch, May 4, 1871; No. 1804, 11-inch, May 5, 1871.
3746 Section of Admiralty turret target No. 34.
3747 do. do. No. 35.
3748 Front of Admiralty turret target No. 34, after rounds Nos. 1808 and 1809 from 11-inch M.L.R. gun. Charge 85 lbs. P. powder. Range 200 yds. May 8, 1871. Target replaced in position.
3749 Bottom of target representing ship's deck, after round No. 1796 from 9-inch M.L.R. gun. Charge 43 lbs. R.L.G. powder. Range 100 yds. May 4, 1871.
3750 Top of do., after rounds Nos. 1796 to 1798, and 1805 to 1807, from 9-inch M.L.R. gun. Charge 43 lbs. R.L.G. powder. Range 100 yds. May 4 and 5, 1871.
3751 Bottom of do.
3752 Front of War Office shield No. 31, after two trial rounds—No. 1801 from 11-inch M.L.R. gun, charge 85 lbs. P. powder, May 5, 1871; No. 1811 from 10-inch M.L.R. gun, charge 70 lbs. P. powder. Range 200 yds. May 8, 1871.
3758 Diagram showing effect of curved fire from 16-pr. M.L.R. gun.
3759 Plan of shield fitted with mantelets.
3760 10-inch M.L.R. gun and carriage, showing proposed method of carrying side-arms of guns mounted behind shields.
3761 4-pr. steel rifled B.L. gun, received from the Prussian Government, June 1871.
3762 do. do.
3763 do. Showing breech apparatus open.
3764 7-pr. bronze M.L.R. gun, weight 199 lbs., mounted on wrought-iron carriage. Abyssinian pattern. May 31, 1871.
3765 7-pr. steel M.L.R. gun of 150 lbs., No. 26, on wrought-iron experimental carriage made in 1869.
3766 12-inch M.L.R. gun, fitted with Mr. Becker's chase sight. June 1, 1871.
3767 Front of W.O. shield No. 31, after proof rounds Nos. 1813 to 1815 from 9-inch M.L.R. gun. Charge 43 lbs. Range 20 yds. June 1, 1871.

R.A. Institution, Woolwich,

28th May, 1872.

THE RANGE-FINDER.

BY

CAPTAIN NOLAN, R.A.

The range-finder has now been in use for some years, and although several descriptions of it have been already given, I believe the present to be an appropriate time for publishing a fresh account of an instrument which will probably be soon tried upon a large scale.

To show the necessity for the employment of the range-finder with artillery in the field, it is essential to prove three points :—

1st—That the range-finder can give the correct distance of an object in a time and fashion applicable to a battery in the field.

2ndly—That to know the distance of an enemy is of the utmost importance to artillery.

3rdly—That it is improbable that this object can be effected by any other instrument differing essentially in construction from the range-finder.

I.—That the Range-Finder can give the correct Distance of an Object in a time and in a fashion applicable to a Battery in the Field.

The proofs adduced upon this point are entirely experimental.

In Vol. VII., Part 2, p. 136 of the "Proceedings of the Department of the Director-General of Ordnance," will be found an account of an experiment which took place at Shoeburyness on the 21st June, 1869, before Colonel Elwyn, Superintendent of Experiments.

Four telemeters, designed respectively by Mr. Adie, celebrated as an optician and inventor; by Colonel Clerk, R.A., Superintendent Royal Carriage Factory; by Messrs. Elliott, the great instrument makers, of the Strand, London; and by Lieut. Nolan, R.A., were employed on this occasion.

Trial of Telemeters at Shoeburyness, 19th May, 1869, before Colonel Elwyn, R.A.

True Distance.	Errors made in determining the distance of a horseman, by the instruments of			
	Adie.	Clerk.	Elliott.	Nolan.
yds.	yds.	yds.	yds.	yds.
865	+ 71	+ 6	+ 15	+ 2
1200	0	+ 19	+ 10	+ 4
1649	− 19	+ 35	− 149	+ 15
1900	+ 12	+ 48	− 190	− 6
2558	+ 156	+ 104	− 158	− 24
2706	+ 244	+ 111	− 6	+ 8
3452	+ 231	+ 300	− 352	+ 22
3380	− 147	+ 217	− 480	− 26
3802	+ 164	+ 115	− 1002	− 8
3040	− 93	+ 160	− 240	+ 4
2717	+ 133	+ 160	− 517	+ 17
2354	− 154	+ 84	− 154	+ 7
1975	− 95	+ 40	− 95	+ 25
1640	− 80	+ 29	− 120	+ 9
1205	+ 31	...	− 25	+ 19
944	− 8	...	+ 16	+ 6

Remarks in report:—"Wind down range, with occasional rain storms." "Colonel Clerk used a base of 100 yds., Lieut. Nolan 57 for the first five ranges, 93 for the last."

Most of Nolan's ranges were taken with a specially drilled squad; but while these were at dinner, some were taken by an ordinary Shoeburyness detachment.

In Vol. VIII., Part 1, p. 77 of the "Proceedings of the Department of the Director of Artillery and Stores," will be found an account of a trial which took place at Aldershot, on three days in October, 1869, under Col. Smyth, R.H.A., and Brigade-Major Oliver, R.A.

The following is an extract from the report made by Colonel Smyth:—

"The guns were worked by Lieut. Gower. The experiments were carried on under many unfavourable circumstances that might arise on active service.

"During the first two days a strong and intensely cold wind was blowing, raising clouds of dust, which several times seriously delayed the observations.

"At Twesel Down the position for the battery was purposely chosen on ground so hilly and broken as to render it most difficult to bring both guns into action and use the instruments at the same time.

"Previous to commencing the third day's experiments, the guns were trotted over rough ground for about four hours, and one of the instruments received a more severe shaking than had been intended, from the lid of its box flying open and remaining so for some time without its being noticed.

"The only difference, however, produced was that on making test observations of already ascertained distances, the ranges given by the instruments were rather less than they had been the first time.*

* I believe the true explanation of the apparent improvement caused by the trotting to be simply that the gunners worked with more confidence on the third day than on either of the two preceding.—J. P. N.

"Lieutenant Gower is deserving of very great credit for the patience and attention which he has devoted to carrying out these trials, and it was gratifying to see how interested the non-commissioned officers and gunners were in the experiments."

Experiments with Lieutenant Nolan's Range-Finder.

Aldershot, 27th and 28th October, 1869.

Position of battery.	Object of which range was taken.	Distance as estimated by Nos. 1. No. 1 Gun.	Distance as estimated by Nos. 1. No. 2 Gun.	Distance by Instrument.	Time.	Distance by Ordnance survey.	Errors of Instrument.	Remarks.
		yds.	yds.	yds		yds.		
Bench Mark, Miles' Hill..	Wash-house chimney......	1900	1200	2508	3·15	2470	38	Deliberate maximum time allowed, 5 minutes.
″ ″ ...	S.W. corner of Pavilion...	2800	3000	2600	3·20	2630	30	Do. do.
″ ″ ...	Flag-staff, Cæsar's Camp	3000	3000	2945	2·45	2910	35	Do. do.
″ ″ ...	Long Hill, Bench Mark...	1500	1300	1165	2·30	1180	15	Do. do.
Long Hill, Bench Mark...	All Saints' Spire	2200	1200	2363	1·20	2350	13	Against time, not more than 2 minutes allowed.
″ ″ ...	Engine-house chimney, reservoir	1000	850	1328	1·15	1320	8	Do. do.
″ ″ ...	Flag-staff, Cæsar's Camp	1900	1600	1824	1·18	1810	14	Do. do.
″ ″ ...	Foresters' Public-house S. corner	1100	960	1172	1·25	1160	12	Do. do.
N.W. corner of Pavilion enclosure	Flag-staff, Cæsar's Camp	2000	2000	1692	3·0	1650	42	Deliberately, but without using the tape.
″ ″ ...	″ ″ ...	″	″	1680	3·0	1650	30	Do. but with tape.
″ ″ ...	Cocked Hat Wood.........	2080	3050	2000	4·30	1970	30	Do. without tape.
″ ″ ...	″ ″ ...	″	″	2000	1·15	1970	30	Do. with tape.
″ ″ ...	Wash-house	2090	6000	3655	2·45	3660	5	With tape, against time, but rising ground in the way. *The delay was occasioned by one of the guns coming into action out of sight of the object.*
Miles' Hill.....................	Foresters' Public-house...	1100	1100	1155	1·22	1160	5	At 20 yards interval, and against time.
″	Staff on Twesel Down ...	3080	1000	1640	1·32	1630	10	Do. do.*
″	N. corner of Cocked Hat Wood.....................	1000	900	770	1·35	780	10	Do. do.
Twesel Down (very hilly broken ground)	S.E. do.	700	600	885	1·30	890	5	Do. do.
″ ″ ...	Staff on Cæsar's Camp ...	2060	2050	2115	1·30	2100	15	At long intervals.
″ ″ ...	Wash-house	4090	4080	3950	2·40	4100	150	Do. deliberately.
″ ″ ...	Spire of All Saints' Church	3000	2100	3180	5·15	3140	40	Do. very bad ground.
″ ″ ...	Wash-house	″	″	4050	2·0	4100	50	Do. (repetition).
″ ″ ...	Bench Mark on Mills' Hill	″	″	1640	...	1630	10	Do. vide above.*
Position in Long Valley...	Wagon moving at a walk towards battery	″	″	780	...	780	0	The correct distances were subsequently ascertained by careful observation of the points placed at the spot the wagons were passing at the instant the range was taken.
″ ″ ...	Wagon moving at a trot towards battery	″	″	795	...	797	2	

The guns to which the instruments had been attached were then trotted for four hours; subsequently the following observations were taken:—

Long Valley.....................	Wagon advancing at a trot	...	...	1405	...	1450	45	Measured by a chain.
Long Hill	Engine-house	...	...	1315	...	1320	5	Deliberately, and with double instrument.
″	Foresters' Public-house	...	...	1142	...	1160	18	Do. do.
″	Staff on Cæsar's Camp ...	...	...	1811	...	1810	1	Do. do.
″	All Saints' Spire	...	...	2349	...	2350	1	Do. do.
″	″ ″	...	...	2349	...	2350	1	Repeated, using *one* instrument only, in 3m. 30s.

(Signed) J. R. OLIVER, Brigade-Major, R.A.,
Superintending Experiments.

N.B.—See Proceedings of the Dept. of the Director of Artillery and Stores, Vol. VIII. p. 77.

The inventor was not present at this trial.

In Vol. IX., Part 1, p. 47 of the "Proceedings of the Department of the Director of Artillery," will be found the reports of seven commanding officers of batteries and of the Commandant, School of Gunnery, on eight sets of range-finders, supplied to them in 1870.

These reports were furnished after three months' trial. The School of Gunnery and six of the commanding officers—Colonel Turner, Majors Byrne and Stirling, Captains Crowe, M'Laughlin, and Smith, speak highly of the range-finder; Captain Thornhill speaks unfavourably.

The following are extracts from the reports of some of these officers :—

Lieut.-Col. Turner, B Bat., 4th Bde., R.A., Dublin :—"I consider the instrument (with the exception of the tape) *a great success*, and will add *greatly* to the efficiency of a battery in the field."

Major Stirling, E Bat., 11th Bde., R.A., Aldershot :—"I consider the instrument a most valuable addition to the equipment of a battery, and likely to increase very considerably its efficiency on service.

"The instruments have been constantly carried with the battery, and have never been out of order. Their use is learnt in a few lessons by men of ordinary education.

"It is stated that, from constantly measuring the ranges, the gunners have improved perceptibly in estimating distances by the eye."

Capt. Smith, G Bat., 11th Bde., R.A., Hilsea :—"I am of opinion that the general utility of the range-finder is very great, and will be a great assistance in obtaining ranges.

"A proportion of non-commissioned officers and men have been instructed and practised in the use of the instrument. Ranges obtained agree very nearly with the measured distances."

Major Byrne, A Bat., 14th Bde., R.A., Woolwich :—"The result obtained has been very satisfactory.

"I suggest that the range-finder be carried under the axle-tree arm.

"I have taken frequent opportunities of instructing the non-commissioned officers and men in the use of the instrument. The instrument is understood by them, and there is no difficulty in teaching men of ordinary capacity."

School of Gunnery :—"The ranges are found with great ease and accuracy with the instrument."

Only three officers give the time necessary to take the range.

This Colonel Turner fixes at 1 min. 57 secs.; or, with picked men, 1 minute easily.

Captain Crowe, the only officer whose guns were not properly fitted with *V's*, gives the time from 55 secs. to 3 minutes.

Major Stirling, from 30 secs. to 2 minutes.

The following opinions, extracted from the "Proceedings of the Department of the Director-General of Artillery," have also been given on the range-finder (Vol. VIII., Part 1, p. 76) :—

"Director-General of Ordnance (General Lefroy, C.B.) to Under Secretary of State, 3. 11. 69, states 'that the report of the range-finder is most satisfactory. There is only one error of the instrument' (referring to Aldershot trial) 'of any practical importance, and that was at a distance of $2\frac{1}{2}$ miles.

This instrument has now been tried by the late Ordnance Select Committee, by the School of Gunnery, by the Dartmoor Committee, by the artillery at Aldershot, besides minor trials, and in all cases has done well.'"

"He thinks that no further trials are necessary, and that we need look for no better instrument. Submits that it be adopted, and a provision made for a supply in next year's estimates."

"Proceedings of Select Committee," Vol. VI., p. 367:—

"The Assistant-Director of Ordnance," Colonel Milward, C.B., now head of the Laboratory, "by minute 15. 7. 68, states from personal knowledge of that portion of the system in use by Lieut. Nolan, in Abyssinia, that it is most valuable and useful, not only in action, but under many circumstances constantly arising in a campaign."

The Dartmoor Committee, of which General Dickson, V.C., C.B. (now Inspector-General of Artillery), was President, say—8. 12. 69 (Vol. VII., Part 4, p. 270):—"A range-finder should be carried. The committee are very favourably impressed with Lieut. Nolan's instrument, and recommend further trials with it."

Colonel Elwyn, R.A., then Commandant of the School of Gunnery, says—(Vol. VII., Part 4, p. 283):—

"The unsatisfactory practice at unknown ranges whilst manœuvring rapidly, shows that a large quantity of ammunition may be wasted without the fact being observable from the battery, and points to the necessity of some means being provided for ascertaining in the field, and within reasonable limits, the distance of the object to be fired at. For this purpose, an instrument invented by Lieut. Nolan, R.A., was fitted to two guns of the 12-pr. battery; it was worked by the gun detachments under Lieut. Nolan's instructions, and the ranges were measured with sufficient accuracy in about one minute and a half, or during the time which a field battery must take to come into action and get ready its ammunition for firing.

"This was the only instrument submitted to the committee, and they were so favourably impressed with it that they have recommended its further trial.

"Should this, or some other instrument for the purpose, be introduced into the service, the fullest advantage might be obtained from the guns of precision of the present day—an advantage which was signally lost in the rapid manœuvres at Dartmoor, where the peculiar features of the ground made it most difficult to ascertain the ranges by means of trial shots."

Vol. VII., Part 2, p. 135.—Colonel Wray, C.B. (Member of Department of the Director-General of Artillery), writing 27. 1. 69, on an experiment which he conducted on behalf of the Ordnance Select Committee, at Shoeburyness, "is of opinion that the experiments show most conclusively that very great advantage is gained at a trifling loss of time in coming into action, by the use of this instrument; and by neglecting such a manifest advantage, we are giving up half the benefits of rifled guns."

He states "he is informed that the officer directing the guns (Lieut. W. O. Smith, 4th Brigade, R.A.), which were laid in the ordinary manner, is more than a fair average representative of the battery subaltern, and yet whereas against a close column or line of troops almost every round of Lieut. Nolan's would have told with deadly effect, two-thirds of Lieut. Smith's would have passed harmlessly to the rear."

"Proceedings of Director-General of Ordnance," Vol. X., Part 1, p. 65.—Extract from "a report, 15. 11. 71, of Colonel Phillpotts, Commanding R.H.A., at Aldershot, upon the 9-pr. and 16-pr. rifled muzzle-loading equipment of horse and field artillery engaged in the autumn manœuvres of 1871":—

"Every battery should have Nolan's range-finders fitted to Nos. 1, 3, 4, and 6 guns. These instruments were most favourably reported on by officers commanding batteries during the manœuvres."

II.—That to know the distance of an enemy is of the utmost importance to Artillery.

It is impossible to establish this point by experiment, until instruments for determining distances have been used in action, but every work upon artillery treats of the importance of knowing the range. The rules of the game of Kriegs-spiel strongly enforce this fact.

Tables A and B have been compiled by a French officer from the results of actual practice with the French field-piece. The 12-pr. Armstrong is more accurate than the French gun of 9 centimetres, but it is improbable that the disparity is sufficiently great to seriously affect the comparisons drawn.

The tables are only made for shot, and it might at first sight appear that they ought to have taken into account the bursting effect of shell; but in a paper opening a new subject, it would be premature to deal with the more complicated projectile until the question had been first ventilated with regard to the simpler.

Table A.—*Showing the number of rounds per* 100 *which would strike a company of* 34 *files in line (on a target* 22 *yds. long by* 6 *ft.* 8 *ins.), calculated for the Canon rayé de* 9 *centimetres.*

Error in estimating the range.	900 yds.	1100 yds.	1300 yds.	1700 yds.
0 yds.	52·4	43·7	37·1	28·3
55 "	50·1	36·1	25	14·8
110 "	30·9	15·7	6·1	1·9

Could we, by losing a certain amount of time at the commencement, ascertain the range as closely as we would like, would it be worth our while to do so at 900 yds. range?

Clearly it would be of no avail to reduce the error below 50 yds., and whether it would pay to lose time in order to keep our error limited to 50 rather than to 100, would depend upon the amount of time expended in determining the distance, and the length of the period for which the battery would be firing upon the same point.

If we suppose that a gun fires one round in the first minute after coming into action, and two rounds in every succeeding minute, we see that it would be better to lay 100 yds. wrong every time than by losing one minute to

reduce the error in range to 50, or even to 20 yds, provided the battery does no remain more than four minutes in action. After four minutes, it would produce an only equally destructive result to consume one minute in ascertaining the range within 50 yds.; but it would save 40 per cent. of the ammunition. In ten minutes, the destructive results would be much greater with a 50-yds. than with a 100-yds. error, even allowing for the minute lost at the commencement.

At 1100 yds., an error of 50 yds. is of no great importance, but an error of 100 yds. produces much worse practice than one of 50; so much worse, that if the battery is in action three minutes, it will be worth while to lose one minute in determining the range within 50 yds., and at the end of five minutes, the battery having originally invested this minute would have produced nearly double the effect of the battery firing 100 yds. wrong.

At 1300 yds., a battery expending one minute in finding the range to within 50 yds.—that is, not firing its first shot for two minutes—would in its first round produce a greater effect than a battery laying its guns 100 yds. wrong, which had opened its fire in one minute, and consequently had in two minutes fired three rounds. In five minutes the former plan would produce double the effect of the latter. At this range (1300 yds.) it becomes for the first time desirable, though still not very necessary, to reduce the error in range below 50 yds. Even should five minutes be lost in ascertaining the range—that is, should a battery so doing not fire a round for six minutes—it would, in four minutes more, have double the effect of one firing away rapidly from the commencement, and an equal total time, or ten minutes, in action, but having an error in the range of 100 yds.

At 1700 yds., a battery keeping the error down to 50 yds., would at the first round—that is, in two minutes—have double the effect of guns laid 100 yds. wrong from the first, and would have in five minutes a five-fold advantage. If the range were *exactly* known, these results would be again doubled—that is, a tenfold advantage would be reaped in five minutes.

Hitherto it has been supposed that the mark fired at would be a company in line; but from 1700 yds. upwards, it will be right to confine our attention exclusively to columns.

TABLE B.—*Showing the number of rounds per* 100 *which would strike columns, calculated for the French field-piece* (9 *centimetres*).

	Column 22 yds. broad, 45 deep.				Column 22 yds. broad, 110 deep.			
Error in estimating range.	1700	2200	2800	3300	1700	2200	2800	3300
0 yds.	38	30·7	20·3	13·3	76·9	63	43·3	28·5
55 "	17·1	14·6	10·9	7·7	46·6	39	27·9	19·3
85 "	6·2	5·8	4·9	3·9	23·7	20·6	15·9	11·8
110 "	1·4	1·5	1·6	1·5	8·5	8	6·9	5·7

This table shows that even at 1700 yds. it would be quite useless to fire at a column 45 yds. deep, unless the range were known to within 100 yds., as only $1\frac{1}{2}$ per cent. of the projectiles would act if the error were so great as this.

Eleven per cent. of the projectiles will tell up to 2800 yds., provided the distance be known to within 50 yds. At 3300 yds., to produce the same effect, the distance must be known to within 30 yds.

French guns of position produce much better results than their field-pieces, when firing against lines of troops, if the range be moderately well known; worse (actually, not comparatively) when there is a considerable error (100 yds.) in the range.

	Reducing the error of the tangent scale from 100 yds. to 50 yds., and losing 1 minute in so doing.		
	If the battery is 2 minutes in action.	If the battery is 5 minutes in action.	If the battery is 10 minutes in action.
Firing at a Company. 900	Is of no use.	Is useful.	Increases des. effect 50 per cent.
〃 〃 1100	Is of no use.	Is very useful.	Doubles des. effect.
〃 〃 1300	Is very useful.	Doubles des. effect.	Quadruples des. effect.
〃 〃 1700	Doubles des. effect.	Increases five-fold des. effect.	Six-fold.
Columns 45 yds. deep. 1700	Quadruples des. effect.	Increases seven-fold des. effect.	

At 1700 yds. range, three French guns of position, firing at a company in line, with errors of 0, 50, and 100 yds. respectively, would produce results in the proportions of 80, 25, and 1.

The above reasoning is based upon data supplied by the French field guns. It may be asked, How would the use of other and more precise pieces modify the above conclusions?

In point of accuracy, I believe the French guns to stand at the bottom of the scale, then follows the Austrian muzzle-loader, then the new muzzle-loading 9-pr., then the 12-pr. Armstrong breech-loading gun, and at the top, the Prussian or Russian Krupp's breech-loader.

The question arises, Which requires a range-finder the more, an accurate or an inaccurate gun? I think a good deal might be said on both sides. The latter, owing to its greater distribution of fire, will actually hit the target oftener than the former, when there is a certain relation between the average variation in the range of the gun and the error made in estimating the range; while, on the other hand, the more accurate the gun, the easier is it for an observer to correct the range by trial shots.

Now comes the question of how nearly the range can be found by trial shots; and upon this point there still lies considerable room for investigation.

As to hoping that mere guessing or estimating will ever give ranges of 1500 or 2000 yds. accurately, a glance at the Aldershot table (p. 163) ought alone to suffice to dispel any illusion on that head.

I have heard many men say that with trial shots they could always ascertain the range. I remember one captain in particular, who, at practice on the Shoeburyness sands, pointed out to me what good shooting he had made with trial shots, and I had some difficulty in convincing him that when an officer has the results of his first rounds telegraphed back to him by the range party, he is hardly imitating closely the conditions of service.

At Magdala, the Armstrong 12-prs. were fired for twenty minutes, and their shell were supposed to burst on the gate, while in reality they were bursting 500 yds. short. On the error being pointed out by a detachment of artillery in their front, but out of their line of fire, these same guns made very good practice.

The best *fair* trial shot practice I have ever seen was made by Captain A. W. Duncan, on the Shoeburyness sands. He fired twelve separate series :*—

	Actual range.	1st guess.	Corrected to
A	1570	2500	2200
B	1250	1200	1220, 1250, 1260
C	1800	1900	1950, 1970
D	1805	1200	1300, 1400, 1600
E	1250	1200	1250, 1300, 1250
F	1776	2000	1900, 1850, 1800
G	2001	2100	2300, 2200, 2250
H	1763	2200	2150
I	1444	1500	1400, 1450
K	1231	1300	1200
L	1416	1450	1550, 1500
M	1865	2200	2100, 2000, 1700, 1800

On average ground, and with percussion fuzes, the ranges may be found by trial shots up to 1300 yds., as a rule; but to effect even this it is necessary that the atmosphere should be tolerably clear, the Nos. 1, or pointers, not only good shots, but all laying their guns after the same fashion, and the officer practised.

Over 1500 yds. it is very difficult to find the range by trial shots; but when the enemy is on an incline, sloping towards the fire, the range may be obtained up to any distance.

When, on the other hand, the ground, both in front of and behind the enemy, is hidden by hedges or by undulations, or when the air is thick with smoke, dust, or mist, then at any distance it is difficult to find the range with trial shots; yet these are precisely the positions which an enemy will seek, and the conditions of atmosphere often experienced in action.

* See Vol. VIII., Part 1, of "Proceedings of Department of Director of Artillery and Stores.

January 21, 1869, *at Shoeburyness. Firing before Colonel Wray, R.A., two guns without finders against two with.* 1000 *to* 2000 *yds. range.*

Two guns without finders.		Two guns with finders.	
6 yds.	over	Through.	
8 〃	〃	1 yd.	short.
20 〃	〃	1 〃	〃
22 〃	〃	2 yds.	〃
59 〃	〃	7 〃	〃
60 〃	〃	7 〃	over.
64 〃	〃	10 〃	short.
64 〃	〃	21 〃	over.
68 〃	〃	22 〃	〃
74 〃	〃	23 〃	〃
76 〃	〃	25 〃	〃
132 〃	〃	28 〃	short.
140 〃	〃	30 〃	〃
146 〃	〃	31 〃	〃
164 〃	〃	36 〃	〃
170 〃	〃	75 〃	〃
186 〃	〃	103 〃	〃
200 〃	〃	800 〃	〃
250 〃	〃	850 〃	〃
Premature		900 〃	〃

"The shortness of the three last shots was owing to Lieut. Nolan looking at the wrong target after the first round."

The first round of the series to which these three shots belonged struck the sands at 21 yds. from the target, distant 1940 yds. The twenty rounds were fired in five series of four rounds each.

The following table shows the 9-pr. practice at the Dartmoor experiments—the first day's practice, when the sighting of the guns and the proper lengths of fuze were unknown, being left out.

Unfortunately, all the 12-pr. practice was either at known ranges, or the results were mixed up with known range practice; so no data can be obtained from the 12-pr. practice for this purpose. (See "Report of Dartmoor Experiments," from which this table has been compiled, or "Proceedings of Department of Director of Artillery," Vol. VII., Part 4) :—

9-*pr. Target Practice at Dartmoor, with Segment and Shrapnel Shell.*

Date.	No. of rounds.	No. of hits.	Ranges.	Size of target.	No. of rows of target.	Average No. of hits per round.	Average No. of hits per round when the targets are supposed to be reduced to a common area.	How range was obtained.	Rate of fire.
June 16......	30	541	1000	54 × 6	2	18	18	With range-finder.	Deliberate.
July 2......	45	1205	1000	54 × 6	2	26	26	〃	〃
June 22......	45	433	1300	54 × 6	2	10	10	〃	〃
June 23......	45	446	1450	81 × 9	1	10	9	〃	〃
June 24......	108	613	900, 1300, 1500, 1700, 1200, 800	180 × 9	1	5·7	2·3	By trial shots, but the ground was well known.	1 min. 10 secs. per round.
July 1......	30	419	900	54 × 9	2	14	10	By trial shots, ground moderately known.	0 min. 50 secs. per round.
July 1......	30	392	900	54 × 6	2	13	13		Deliberate.
June 30......	97	118	1300	54 × 9	2	1·3	0·9	By trial shots, ground unknown.	0 min. 25 secs. per round.
June 30......	48	265	1400, 1180, 750, 1220	54 × 9	2	5·4	3·6	By trial shots, ground unknown.	1 min. 0 sec. per round.

Many officers will probably fancy that they have made better trial shot practice than this; but as far as my experience has gone, it is very hard to get a battery to make any *bonâ fide* trial shot practice at all.

At Aldershot, the precautions taken for safety necessitate practice from the same spot, or rather along the same line, and the landmarks there have become well known.

When firing at targets in the sea the range is often unknown, but the range party, at all sea practice, invariably put down the shot as striking much nearer the target than it really does.

Almost the only circumstances under which there is *bonâ fide* firing at unknown ranges properly recorded in this country, is when guns go on the sands at Shoeburyness; and even there, unless expressly forbidden, the range party will give vent to their burning desire to communicate immediately the results of the first rounds to the firing party—thus vitiating the whole day's work.

III.—That it is improbable that the distance of an enemy will, for Artillery purposes, be more effectually obtained by any instrument differing essentially in construction from the Range-Finder.

To prove this point is a difficult task, as the proof of a negative proposition must always be. It must also be understood that of the hundreds of instruments devised for this purpose, there is not one that will not, under certain circumstances, give some favourable results, and that most of them are superior to the trial shot system.

I will class all the instruments that are known under three heads, and although I acknowledge that this classification is not perfectly exhaustive, it will include all worth noticing:—

1. Telemeters that use the height of a man in the enemy's ranks as their base.
2. Telemeters containing their own base.
3. Instruments that employ a fixed base of definite length—generally 100, 50, or 25 yds.

Class 1.—The best type of this class is Elliott's telescope. A thread fixed in the focus of the telescope is pointed at a man's feet; the movement of a ring brings a movable thread on the man's head; an arrow then points out his distance. A second scale does for horsemen.

Perfect as is the workmanship of this telescope, it will never suffice for artillery—

(1) Because men vary in height.
(2) Because their feet are often concealed.
(3) Because a distance is often required where there is no man present.

Class 2.—Instruments containing their own base.

Adie, Clerk, Guatier, Piazzi Smyth, Otto Struve, have made good instruments of this class.

All these instruments agree in having for base their own length, and in superposing, rendering identical, or measuring the distance between two images of the observed object which enter at either end of the telemeter, and which are brought together at the centre by prisms, mirrors, or lenses.

These telemeters are generally a yard long, as it would be difficult to use longer ones in the field.

These instruments may become useful auxiliaries in action, but they can never be sufficient alone for artillery purposes—

(1) Because they require exquisite fineness of observation.

(2) On account of the extreme minuteness of the divisions on the scale.

(3) From their liability to being thrown out of adjustment, and the difficulty in detecting the error.

1st. If instead of exactly superimposing the two images, an error of an inch is made, there will be an error at 1800 yds. of 50 yds.

2nd. To give good results, the scale must be divided to seconds; and any one who has used either a sextant or a theodolite knows how difficult it is to read hurriedly to seconds.

3rd. The third is, however, the fatal drawback; it is quite evident that the slightest flexure in the base must ruin the results, not by sensibly affecting the length of the base, but by completely altering the set of the optical ends of the telemeter. In addition to this, the prisms, lenses, or mirrors of all instruments are liable to slight alterations of position or shape.

These arise from the unequal bearing of internal strains, and from changes of temperature; all human workmanship is liable to derangement from these two causes, but the effect is intensified in this class of instruments from the smallness of the base, and from the liability of the base to change its shape.

Some reliance could, however, be placed on these instruments were it possible to detect their error, and to allow for it. But this I consider impossible, unless another class of instrument is also carried.

Colonel Clerk proposes to test his instrument by measuring 100 yards by a cord, and testing on this known distance.

This remedy is fallacious, because if the 100 yards is measured only 9 inches wrong, the telemeter will, at 3,000 yards, be 225 yards wrong.

Class 3.—Instruments which use a fixed base.

Nearly all these use bases of 100 yards, and employ one instrument to fix a right angle, and another which measures a second angle.

Colonel Clerk, however, used two angle measurers (sextants) in a system distinct from that noticed in Class 2.

The objection to a fixed base is insurmountable, as ground—particularly the little hills for which guns instinctively make in combat—varies too much in shape. It has been endeavoured to overcome this difficulty by making out tables, but that interferes with the requisite simplicity; certainly, if the tables are made out for every

10 yards only, there is not much to complain of on this score, but then elasticity in the base is not sufficiently acquired; if the tables are made out for *each* yard complication ensues.

The majority of these instruments only measure one angle; this is again open to the objection of rigidity, ground not always admitting of a right angle being observed easily. To be able to use any chance base that may arise is, I consider, an essential feature of an instrument for measuring distances, and this can only be practically effected by the use of a mechanical calculator. This is one of the leading features of my range-finder. A decimal notation for the scale I also consider very useful, though not essential for success. It must be remembered that this class of instruments is to be considered in a totally different light from the two former classes, as, while the latter fail because they cannot be depended on to give the true range, there is no doubt that any one of the 3rd Class can be depended upon to ascertain the distance, provided the base used is sufficiently large, and if other circumstances are favourable. This 3rd Class may be sub-divided into two sub-classes.

1st. Those which require stands.

2nd. Those which can be used without stands, and which are reflecting instruments.

As to the first sub-class, it seems impossible that any of these could, if fixed on guns, compete with the range-finder.

1st.—Because all lack the mechanical calculator, which enables my instruments to work with any base.

2nd.—Because the decimal notation gives the range-finder a superiority in point of simplicity.

3rd—Because all these instruments lack the *V's*, and the consequent rotary motion round the line of sight which my instruments enjoy.

It has been said that the range-finders should be supplied with stands, so as to make them independent of the guns. I have always disliked countenancing a step which might tend to divorce the instruments from the guns; still, perhaps it might be advisable to adapt some *existing* article of equipment—say the camp kettles, to act as stands on very occasional emergencies, the gun always being looked on as the main stand.

The second sub-class are the reflecting instruments, notably the sextant; of these, I believe that far the best is my infantry range-finder, which consists of a pair of sextants, carried either separately or in the butts of two rifles; the advantages enjoyed by these over other reflecting instruments are:—1st, that they are provided with a mechanical calculator, carried also in the butt of the rifle; and 2nd, that the notation is decimal; they are of course neither more nor less accurate than other sextants of similar size, but the decimal notation makes them simple, and the calculator imparts the necessary elasticity.

These, and all other sextant arrangements are, however, unsuited to the exigencies of field artillery.

1stly—The sextants cannot, at 2000 or 3000 yds., work with small bases. In skilled hands, on some days, they will give good results with

100 yds. base, at other times they will, apparently, unaccountably fall off: the explanation being that the address required for very accurate work cannot be always maintained.

2ndly—When telescopic power is adapted to sextants they become clumsy.

3rdly—The same man cannot observe from both ends of the base; this last objection is of no consequence when *good* distinguishable points, such as a steeple, a target, or an *isolated* man are observed, but it is fatal when the points are bad or confused, as they will probably be in the field.

In addition to the three grand classes of instruments discussed above, other systems have been proposed, such as finding ranges by the focussing of a telescope, or by similar triangles; I have not entered upon these because they are all thoroughly unworkable.

Nor have I touched on the instruments which are used from heights.

To sum up, I do not see how any instrument can possibly be constructed to equal the range-finder, unless it adopts the principle on which the range-finder is founded, and the artifices which have enabled that principle to be applied to artillery purposes.

The principles which I have adopted arose from the following idea having occurred to me.

I observed that all surveyors' plans for finding distances succeeded, and that they invariably employed three variable quantities—the base and the two base angles; but that, on the other hand, all military plans for finding ranges depended on, at most, the variation of two quantities, and nearly all upon the variation of a single quantity, and that all military plans had failed. The range-finder is the surveyors' method adapted for use in action and by gunners.

The same result might have been attained by using sextants, but I consider them unsuitable for artillery purposes, for the reasons above given. In thus rejecting them, I do not depart from my main idea, as all writers on surveying agree that the sextant is not a convenient instrument with which to take the angles of terrestrial objects.

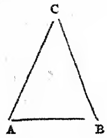
THEORY.

I had not originally intended to proffer a theoretical explanation of the range-finder, because it can be correctly worked without any knowledge of mathematics, and because the very name of theory might, in some minds, create prejudice against the instrument. I, however, annex the following account of the principles upon which the range-finder is based, in compliance with a request of Colonel Gordon, C.B., when Chief Instructor of Gunnery, Shoeburyness.

The experience of ages has shown surveyors that the most convenient way of measuring distances is to measure a variable base, and two variable base angles. They scarcely ever follow any other method, such as using a fixed base, or one fixed angle.

I imitate the surveyors' proceeding, but add these conditions, that the base must be short, and each of the base angles greater than 80°, and less than 100°.

The surveyor calculates the required distance AC from the formula



$$AC = AB \frac{\sin B}{\sin (180° - A - B)}.$$

If B be a right angle, sin. $B = 1$, and then $AC = \sin. \frac{AB}{(180° - A - B)}$

$$\begin{aligned} &\text{If } B = 85° \text{ or } 95° \\ &\text{Sin } B = \cdot 997; \\ &\text{If } B = 80° \text{ or } 100° \\ &\text{Sin } B = \cdot 986. \end{aligned}$$

Therefore, should we treat sin B in every case as equal to unity, the actual distance AC would, when $B = 85°$ or $95°$, be less than the *calculated* AC by 3 yards per 1,000, and when $B = 80°$ or $100°$ by 14 yards per 1,000.

On the range-finder system sin B is always supposed equal to unity, consequently it is theoretically *possible* to have a mistake of 14 yards per 1,000; but in practice such an error can only take place when the angles differ more than 5° from a right angle.

The formula employed is then:

$$AC \text{ or Range} = \frac{AB}{\sin (180° - A - B)},$$

consequently AB, A, and B have to be found.

The process of using the range-finder consists in laying the main telescopes of the angle-finders upon a distant object, and the short telescopes upon each other, or, for convenience, on their cases, and also in measuring the distance between the axes of the main telescopes (or for convenience the distance between the trail handles, which are 17 inches nearer to each other than the axes, this being allowed for in the tape). We thus get AB, A, and B, and the roller works out the formula:

$$\text{Range} = \frac{AB}{\sin (180° - A - B)} = \frac{AB}{\sin (A + B)}.$$

How does it work out this formula?

The first step is evidently to add A to B.

This is done by bringing a mark on the addition-scale of the roller under a quantity $=$ to A, and taking beyond this mark a number $= B$, over this number will be found the quantity $(A + B)$.

Having got $(A + B)$ we use the upper circumference of the roller to find $\frac{AB}{\sin (A + B)}$. The line F on the roller is marked with common numbers 10, 20, 30, 40, &c., but these numbers are at distances apart, represented by the differences of the logs of 20 and of 10, of the differences of logs 30 and 20, of logs 40 and 30, &c. The line E has inscribed upon it, in a similar fashion, a scale corresponding to the logs of the sines. E and F then give us a contrivance for finding

$$\begin{aligned} \log AB - \log \sin (A + B) &= \log AC \\ &= \log \text{Range}. \end{aligned}$$

Instead of degrees and minutes on the scale for measuring the base angles, I employ a decimal division. Each of the range-finder's divisions is equal to $1\frac{1}{2}$ minutes, consequently 100 of the divisions $= 2\frac{1}{2}°$.

On this notation	$2\frac{1}{2}°$ would equal	100
	$5°$ „ „	200
	$100°$ „ „	4000
	$170°$ „ „	6800
	$172\frac{1}{2}°$ „ „	6900
	$175°$ „ „	7000
	$177\frac{1}{2}°$ „ „	7100
	$180°$ „ „	7200

But for military purposes, it is clear that the sum of A and B or $(A+B)$ would, out of 1,000 cases, be roughly—

900	times between	$177\frac{1}{2}°$	and	$180°$
90	„ „	$175°$	„	$177\frac{1}{2}°$
9	„ „	$172\frac{1}{2}°$	„	$175°$
1	„ under	$172\frac{1}{2}°$,		

or in some such proportion, because if we employ a base of 40 yards—

All Ranges over 915 yards will give $(A + B)$ over $177\frac{1}{2}°$
„ „ 460 „ „ „ $175°$
„ „ 300 „ „ „ $172\frac{1}{2}°$

and gunners will not measure distances at case shot ranges.

This consideration allows a further simplification of notation, and instead of calling

$172\frac{1}{2}°$	6900
$175°$	7000
$177\frac{1}{2}°$	7100
$180°$	7200,

$172\frac{1}{2}°$, $175°$, $177\frac{1}{2}°$, $180°$, are all alike called 100 or 0. Consequently the instruments only show by how much $A + B$ exceeds $172\frac{1}{2}°$, or $175°$, or $177\frac{1}{2}°$.

If A is recorded on one instrument as 85, B on the other as 90, $(A + B) = 175$, but as the roller does not deal in hundreds, it only shows 75; the hundred is omitted.

There is then a doubt as to whether the sum of $A + B$

$= 177\frac{1}{2}° + 75$ divisions $= 179° \ 22' \ 30''$
or, $= 175° +$ „ $= 176° \ 52' \ 30''$
or, $= 172\frac{1}{2}° +$ „ $= 174° \ 22' \ 30''$
or $=$ &c.

If the base be 40 yards the corresponding ranges are 3660; 740; 370.

It will be seen that between the first and second values there can be no hesitation in practice, while between the second and third there might be some doubt.

But again, in practice it is so simple to keep the base under some rough proportion to the range that this third value need never occur.

To return to theory, let us suppose $A = 81°$ and $B = 98°$,

$$\text{or, otherwise, as } 81° = 32\,(2\tfrac{1}{2}°) + 1°$$
$$\text{and } 98° = 39\,(2\tfrac{1}{2}°) + \tfrac{1}{2}°$$
$$A = 32\,(2\tfrac{1}{2}°) + 1°$$
$$B = 39\,(2\tfrac{1}{2}°) + \tfrac{1}{2}°,$$

the range-finders or angle measurers only record the fact that—

$$A = x\,(2\tfrac{1}{2}°) + 1°$$
$$B = y\,(2\tfrac{1}{2}°) + \tfrac{1}{2}°;$$

or, as they express it,

$$A = 40$$
$$B = 20$$
$$\therefore A + B = 60.$$

This 60 may mean 179°, or it may mean $176\frac{1}{2}°$ (the other values need not be considered), neither angle-measurers nor roller tell the gunner which is the true value; but supposing his guns to be 19 yards apart, the rollers say, if the range is 1,083 yards, 60 means 179°; if the range is 310 yards, 60 means $176\frac{1}{2}°$.

The artilleryman's eye must enable him to judge which of the above two is the right range, unless, indeed, he has time to take a second observation with a different base, in which case the true range is repeated, the false ones rejected.

Theory of the Muzzle System of Measuring Angles.

The range can be obtained without using a tape; the object of constructing the instrument so as to allow of this being effected is threefold:—

(1st.) To obviate the damage caused by the loss of a tape.

(2nd.) To be prepared for certain exceptional circumstances in which a tape could not be employed.

(3rd and chiefly.) To allow of the length of the tape being corrected at any moment.

If two guns are placed parallel to each other it is clear that one will always, at the same distance, subtend the same angle when viewed from the breech of the other, also that, when the distance between the guns exceeds ten times the length of a gun, the distance between the guns will vary inversely as the angle subtended.

In finding a range without directly measuring a base, we first lay upon the breech and then upon the muzzle of the opposite gun, which is always practically parallel to that at which the angles are attained, and the roller subtracts the second angle from the first, or M from B. Then the mark at the top of the roller is set to the quantity $B - M$, and it will be found on trial that the tape mark shews the actual distance between the guns.

The explanation of this is, that on the top of the roller is engraved a scale of sines, on line G, to determine the position of the gun-mark on H, of the mark, the distance between two 12-pr. A.B.L. guns was carefully measured, the angles at breech and muzzle found, and their difference, or $B - M$, found. Then the tape on the roller was brought under the distance, and opposite the quantity $B - M$ the gun-mark was made.

This mark was evidently true for this particular case, and truth being always consistent, would be true for all other values of $B - M$.

If a 9-pr. were used, a new mark, similarly obtained, would have to be made in the roller, this being the only change required for the different nature of guns.

From 40 to 0, and again to 30, full figures are used on the top scale; after this come 4, 5, 6, &c.; these really mean second forties, fifties, &c., because, while 40 in full represents 1°, 0 represents $2\frac{1}{2}$°, 30 represents $3\frac{1}{4}$, and the small 4 represents $3\frac{1}{2}$°. Consequently, sometimes when $B - M = 50$, instead of setting to the large 50 it may be necessary to set to the small 5; but a reference to the tape mark, which always points out the true distance between the pieces, dispels all doubt as to which value should be employed.

The rule on this head is, over 38 yards set to full figures, under 38 yards consult the tape mark as to whether full or small figures are to be used.

Theory of the Sun Test.

The sun is at an infinite distance, consequently, when the telescopes are laid upon the same portion of its disc, the two angles of the surveyor's triangle become = to 180°, or 100 on the range-finder scale.

Theory of the Second or Four Angle Test.

In this test we first find the two base angles of the triangle in the usual fashion, we then obtain the vertical angle by subtracting from the exterior angle of a triangle, what Euclid calls the interior and opposite angle.

Now, if the instruments are in good order, these three angles will amount to 180° = on range-finder scale 100. If they, on the contrary, contain an error x, we shall have recorded for the base angles a quantity = true base angles + x. But the vertical angle will still be true, for, suppose the exterior angle contains the error y, the interior and opposite angle must also contain the error y, and then—

as false extr. ang. = true ex. ang. + y.
„ intr. „ = „ int. „ + y.
∴ false extr. ang. − false intr. ang.
= in all cases true extr. ang. − true int. ang.
= vertical angle.

∴ Vertical angle and angles found in ordinary fashion = 1800 ± error of instruments, or base angles found in ordinary fashion + exterior angle, − interior angle = 180° ± error = 100 ± error.

The mathematical aspects of the question are ably given in "Remarks on Captain Nolan's Range-finder," by Captain C. E. B. Leacock, R.A.:—*

"Captain Nolan's range-finder consists of two angle-finders, a measuring tape, and a calculating roller.

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* See "Proceedings, R.A. Institution," Vol. VII., p. 40.

"The angle-finders are identical in general construction, but inverted in details, one instrument being right and the other left-handed.

"Each angle-finder consists of a long telescope, round each end of which is a band, turned truly round. The bands rest on two *Y's*, fixed on the outer side of the barrel of the gun, so that when the telescope is laid in them, the axis of the telescope is parallel to that of the gun; above the telescope is an index plate, graduated in a manner which will be hereafter described; at the rear of the index plate is a pivot, on which a steel limb revolves. Above the steel limb, at the pivot, is fixed a short telescope, which revolves with the limb, and remains constantly at right angles to it. The limb and short telescope receive their motion from a screw fixed on the index plate, and working through a nut on the steel limb. The short telescope is protected by means of a tin case, to the inner lip of which is pasted a white paper ring, This case does not revolve, but is fixed at right angles to the index plate, a hole being cut in its side so as not to interfere with the index bar.

"The tape is an ordinary measuring tape, working on a reel. At the loose end is a hook, which, when the tape is used, is hooked to the inner trail-handle of one gun, and the reel is then carried over to the trail of the other.

"To measure the range, by means of the instrument, two guns are used. They are drawn up at an interval of about 40 yds., and are generally dressed so that the object will be directly in front of some point in the inverval. Each gun is then laid on the object, and the interval from inner trail-handle to inner trail-handle measured. The short telescope of each finder is then turned on the vertical axis of the white ring on the lip of the case of the other. This axis is marked by a red spot on the highest and lowest points of the circumference of the ring. The angles between the long and short telescopes will consequently be the base angles of the triangle ABC, formed by the object and the two guns, and their sum will be the supplement of the angle BC. (See Diagram I).

"Now, as we may fairly assume our range over 500 yds., AB and AC are very large in proportion to BC; and as the point A is directly opposite some point in the base BC, the length of the side BA, CA, will be much the same for any particular magnitude of the angle BAC, whether the triangle BAC be isosceles or not; and we may therefore treat the triangle BAC as an isosceles triangle of known base and known angles, of which it is required to find the sides. (The error resulting from this assumption will, hereafter, be proved too small to matter in practice.)

"Our formula will be

$$r = b\frac{\sin\frac{\pi - a}{2}}{\sin a}$$

$$= b\;\frac{\cos\frac{a}{2}}{\sin(\beta + \gamma)}$$

$r = \text{range} = AB = AC$,
$b = \text{base} = BC$,
$a = \angle BAC$.

"Now, as a is very small—for it cannot exceed 5°, as an isosceles triangle with base 40 yds. and apex 5° will have sides only 456 yds. in length—we shall, as will hereafter be proved, incur but slight error from making $\sin \frac{\pi - a}{2}$ or $\cos \frac{a}{2}$ equal to one, and writing our formula

$$r = \frac{b}{\sin (\beta + \gamma)}.$$

"We shall, hereafter, see that from this formula is derived the principle on which the calculating roller is constructed.

"We now proceed to read the base angles by means of the index plates of the angle-finders.

"On these plates the circle is divided into 144 divisions (of 2° 30′ each), which are again subdivided into 100 subdivisions (of 1′ 30″ each). The actual portion of the circle graduated on the index plate is only about eight divisions, or 20°. Tenths of divisions only are graduated on the plate, but the angles may, by means of a vernier on the steel limb, be read to as little as half a subdivision. At each of the divisional graduations is 0, the subdivisional graduations being marked from 1 to 99—the numbers running from left to right on left-handed instruments, from right to left on right-handed ones. The instruments will, consequently show, not the exact magnitude of the angles ABC and BCA, but merely their excess over the next lowest round number of divisions. Thus, if the steel limb EB be immediately over the long telescope, the lines EB and AB will coincide, and therefore the angle ABC coinciding with the angle EBC, will be a right angle, or 36,00 (thirty-six divisions no subdivisions). A zero must, therefore, be marked on the index plate, immediately above the axis of the long telescope, to serve as a starting point, from which the plate is graduated right and left. If we turn the short telescope so as to diminish the angle ABC to, say, 35,71, the arrow head E will point to 71, and if we diminish ABC to 35,00, the arrow head E will again point to a zero. (See Diagram I.)

"Now, let us suppose that having laid our instruments in the manner above described, we have read 60 at B, and 80 at C, adding these two together, we have 140. This being more than a division, we cut off the first figure, and read 40. We now know that the sum of the base angles exceeds some exact number of divisions by 40 subdivisions, or to use a symbolical expression, that

$$\beta + \gamma = 100\, m + 40.$$

"Now, we may assume that a lies between 20 and 2,00, for with the latter of these values a base of 40 would give a range of 456 yards, and with the former a range of 4560. Hence m must be either 70 or 71—the latter value being rejected when the readings add up to more than 80. Readings below 80 render possible two different values of m, and consequently two apices of different magnitude, and two ranges. The two ranges, however, will be so different that it will be impossible to fail to distinguish the true from the false; for, let us have read n subdivisions,

then our two ranges will be

$$r=\frac{b}{\sin\ (70{,}00+n)}=\frac{b}{\sin\ (2{,}00-n)},$$

$$R=\frac{b}{\sin\ (71{,}00+n)}=\frac{b}{\sin\ (1{,}00-n)},$$

"But $2{,}00-n$ is more than double $1{,}00-n$, and small angles vary almost as their sines; therefore, the greater of the two ranges will at least be double the less.

"We now proceed to describe the calculating roller, and show how, by its means, the formula

$$r=\frac{b}{\sin\ (\beta+\gamma)}$$

may be solved, and the sides of the triangle BAC obtained without actual computation.

"The roller is a built-up cylinder, consisting of a body and two rings, these rings being free to rotate round the axis of the cylinder. The lower rim of the body and the upper rim of the lower ring are marked from left to right with 100 equal graduations, corresponding to the number of subdivisions in a division; by means of these rims the readings at B and C may be added together, and if their sum exceed 100, the first figure will be cut off. At the zero point of the lower ring is marked the word "BREECH." This is brought opposite the reading of the first angle-finder (60), when the reading (80) of the second angle-finder on the lower ring will come under (40)—the sum of the two readings less 100—on the body.

"This will be seen in Diagram II., where the two rims are represented as if in one plane, in order that all parts of them may be visible at once.

"On the lower edge of the upper ring is graduated, from left to right, a scale, giving the differences of logarithms of all numbers between 400 and 4000, each logarithm being marked with the number to which it belongs. The size of the graduations is so proportioned to the size of the roller that log $4000-\log 400$ or unity is exactly one circumference of the circle, and the points 4000 and 400 consequently coincide; while, as all powers of ten have logarithms free from fractions, the point at which 1000 is marked will be the true zero point of the logarithmic scale.

"On the upper edge of the body is graduated from right to left a scale giving the differences of logarithms for the sines of all angles between 71,80 and 70,00, which are the greatest and least values the sum of the base angles can have. As the sines of very small angles are proportional to the angles themselves,

$$\sin 2{,}00=10 \sin 20\ ;$$
$$\therefore \sin 70{,}00=10 \sin 71{,}80.$$

Hence the difference between their logarithms will be unity, or one circumference.

"Each logarithmic graduation in this scale is marked with the number of subdivisions in the angle to whose sine it belongs.

"As sin 71,77·18=·01, log sin 71,77·18=−2, and it is at 77·18 that the zero point of the lower logarithmic rim will fall, an arrow-head is marked here, and the word "TAPE" written beneath it.

"From the figures on the lower rim of the body to the corresponding figures of the upper rim, diagonal lines are drawn. These in no way affect the principle of the instrument, and serve only to guide the eye.

"We will now describe the use of the roller.

"As soon as the number of yards in the base is known, the upper ring is turned round until that number comes opposite the arrow-head marked "TAPE." The two readings of the angle-finders are then added together, as already described, by means of the lower ring. The number representing their sum on the upper rim of the body will be opposite the range on the upper ring.

"For, by the formula,

$$r = \frac{b}{\sin(\beta + \gamma)};$$

$$\therefore \log r - \log b = -\log \sin(\beta + \gamma).$$

"But $\log r - \log b$ is the distance from the point on the upper ring, graduated r to that graduated b; and $-\log \sin(\beta + \gamma)$ is the distance from the arrow-head to the point on the upper rim of the body graduated $(\beta + \gamma)$; the difference in sign corresponding to the contrary directions in which the two logarithmic scales are graduated. Therefore these two distances must be equal.

"But the graduation b coincides with the arrow-head; therefore the graduations r and $(\beta + \gamma)$ must also coincide.

"We have already stated that, for readings less than 80, two values of $(\beta + \gamma)$ are possible, and that we have consequently two ranges given; but that one being more than double the other, they were easily distinguished. A reference to Diagram II., fig. 2, will show this to be the case.

"We now proceed to the method by which the range is ascertained with one finder only.

"The guns are dressed so as to be in line with some object to the right or left, and laid on the object aimed at. The angle-finder is then placed first on one gun and then on the other, and the short telescope is each time laid on the object to the flank, the long one on the object aimed at. We thus read the angles β and δ (Diagram I.)

$$\text{Let } \beta = 100\, m + p.$$
$$\delta = 100\, n + q.$$

Then

$$\begin{aligned} \beta + \gamma &= 72{,}00 - \alpha, \\ &= 72{,}00 - (\delta - \beta), \\ &= 72{,}00 - \{(100\, n + q) - (100\, m + p)\}, \\ &= (72, + m - n)\,.\; 100 - (q - p). \end{aligned}$$

Hence we have the rule—

"From the gun-number of the gun nearest the square object take the gun-number of the gun furthest from the square object, and subtract the difference from 100.

"In working without a tape, we have to lay one angle-finder first on the breech and then on the muzzle of the other gun, then, taking the triangle

BCH as an isosceles triangle of very small apex, we calculate b, knowing the length of our gun, from the formula

$$b = \frac{l}{\sin\theta} = \frac{l}{\sin(\gamma - \phi)}.$$

"There is a special scale for solving this formula on the top of the roller. Its general principle is similar to that of the scale on the body of the roller.

"We have, in the course of the forgoing demonstration, made use of four assumptions, none of which are strictly true, and from each of which an error will consequently result.

"These are:—

(1) That when in a triangle *BAC*, the apex *A* is directly opposite some point in base, and the angle α is small, the length of the side *AB* will be much the same, whether the triangle be isosceles or not.

(2) That when α is small

$$\sin\frac{\pi - \alpha}{2} = 1.$$

(3) That $\sin 2{,}00 = 10 \sin 20$.

(4) That the angles read by finders are the true base angles of the triangle *BAC*.

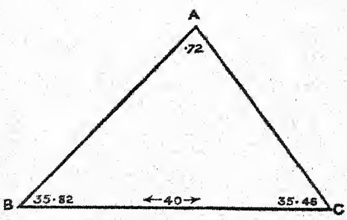
"We will first examine the errors produced by each of these assumptions separately, and afterwards see how their combined result affects the range in practice."

Captain Leacock, whose paper will be found in the "Proceedings of the Royal Artillery Institution" for November, 1870, then proceeds to show that, in the first case, the resulting error will have a maximum in excess of 1·31 yds., or defect of ·44 yds. The second may give an error of ·43 yards. The third an error of 1 yard per 1000 of the range. The fourth will give a maximum error of 2 per 1,000 in excess.

Captain Leacock then continues as follows:—

"Let us now assume a case, and see what will be the difference between the sides of the triangle, as obtained by the calculating roller, and as obtained by the ordinary method.

BC is the known base, *A* the vertical angle in the above reasoning, but at pages 175 and 176 the supposed triangle has for known base *AB*, and for vertical angle *C*.



Let BC = 40 yds.

$ABC = 35{,}82 = 89°33'$

$ACB = 35{,}46 = 88°39'$

$71{,}28 \quad 178°12'$

$\therefore ABC = 72 = 1°48'$

and will be read by the angle-finders

$$72 - \frac{72}{480} \text{ or } 71{\cdot}85 = 1^\circ\, 47'\, 46{\cdot}5''.$$

DIAGRAM I.

Fig. 1.

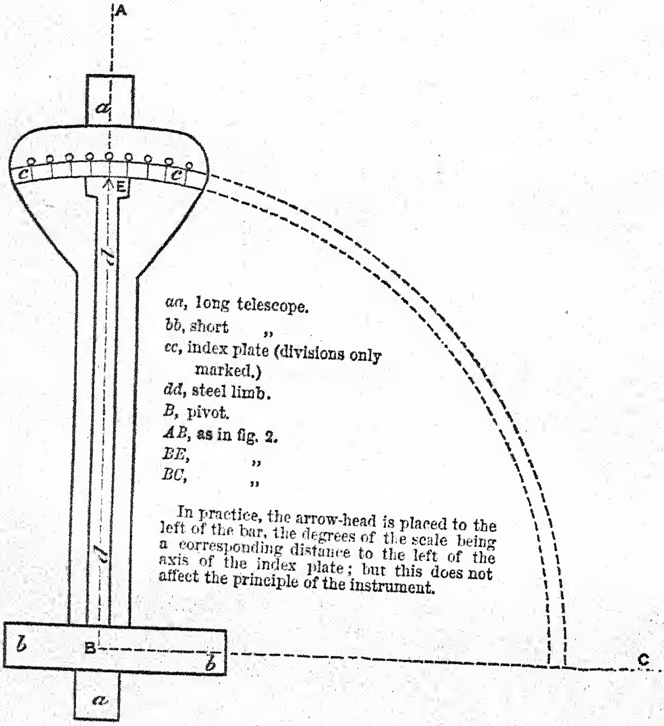


Fig. 2.

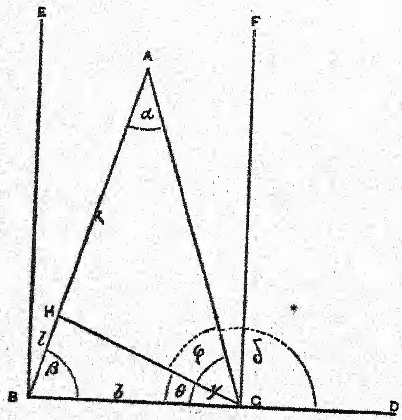


Diagram II.

Fig. 3.

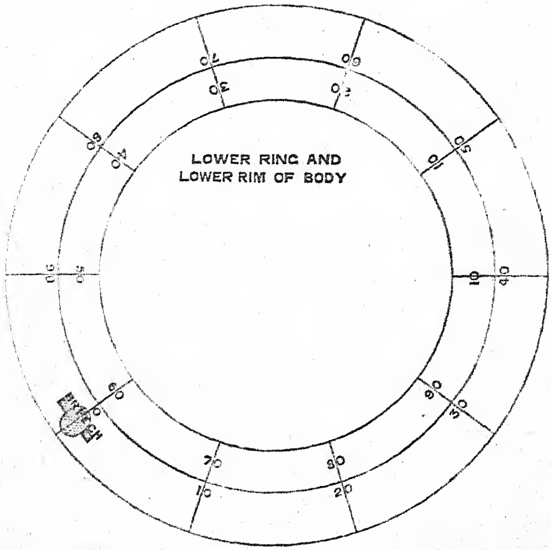
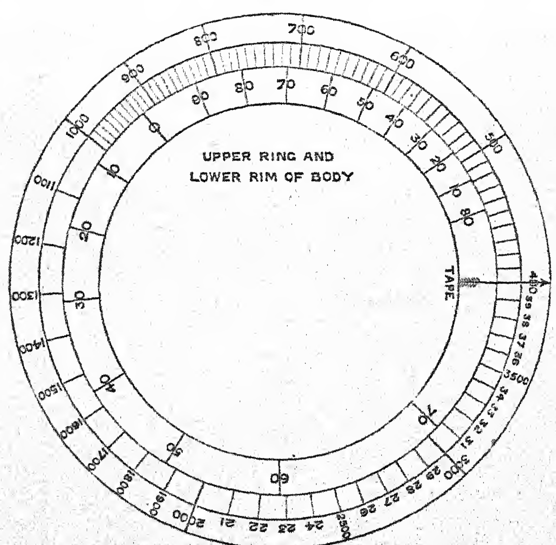


Fig. 4 represents lines E and F on the roller; on the roller, however, these lines are wrapped round the circumference of a cylinder, while in the drawing these lines are represented by discs.

Fig. 4.



Introduction of Range-finders into the Service.

For all guns, except perhaps mountain guns, the same pattern range-finder ought to be used, but the rings on which the angle-finder rotates may have to be placed in different positions, for example, the range-finder, which suited the 12-pr. Armstrong, in being changed to suit a 9-pr. rifled muzzle-loader, had a new ring put on $3\frac{1}{2}$-in. in front of the old rear ring; with this alteration the range-finder fitted either gun.

The reason for this change depended on the fact that the breech of the 9-pr. muzzle-loading gun was hid by its wheels, and the range-finder had to be drawn $3\frac{1}{2}$-in. back to be seen from the opposite gun.

This point being allowed for, the same range-finder ought to suit any gun.

We have then to consider the *V's*, the best position for which is in the centre of the gun, the rear one at the extremity of the breech; but if the gun is centre-sighted, the *V's* must be placed at the side of the gun; and although the want of symmetry will be objected to, it is better to fit them, when not in the centre, on half of the guns to the right, and on half to the left.

The second point to consider is, whether the guns are, or are not, provided with traversing screws; if they are, plain *V's* will do, but if not then the rear *V* will require a traversing screw. It may be objected that boring holes in the gun to fix in the *V's* will weaken it; but calculation showed that the 12-pr. Armstrong was weakened less than $\frac{1}{200}$th by such holes.

The range-finder was, however, at first experimented on without boring these holes, by fixing the front *V* with a large iron clamped ring on the gun, the rear *V* having for a stalk the shank of a tangent sight. For experimental purposes this does well, but the ring occasionally shifts its position when the gun is fired; it is, however, easily tapped back into its place by a hammer.

The tapes recommended are 70 yds. long, but it will be best to have them marked in whatever fashion the soldier is most accustomed to measure; these units need not be the same as that in which the range is given.

For example, the infantry range-finder has the tape graduated in paces, but the calculator gives the answer in yards, because the infantry soldier steps paces better than yards, and his rifle is sighted in yards.

Boxes.

I consider it almost essential that the range-finder be carried in the axle-tree box. This involves the sacrifice of one or two rounds of case per gun, which I look upon as useless, but many artillery officers are very fond of it—it always looks well in artillery returns to have expended case. There will then always be a contest against devoting one axle-tree box to a range-finder.

It is best to procure the range-finder from an instrument maker, but to make the boxes and the *V's* in an arsenal; however, with the 20 sets of range-finders, at least one set of *V's* and boxes should be procured, one pair of spare steel arms, and short telescopes, and some spare screws and drills.

When the instruments are made their distribution must be considered.

I find that the natural impulse is to distribute one set to each battery, that is the 20 sets to 20 batteries, this, however, I consider a *mistake*.

The best plan will be, if there is a large camp which has a good artillery practice ground, to send the whole of the 20 sets to it; if there is no practice ground near the camp, then to send 4 sets to the practice ground, 12 sets to the camp, to be distributed among 6 batteries, that is 2 sets to each battery, and to leave 4 sets with one officer.

This officer should devote himself to becoming well acquainted with the instruments, and although he will probably be a young officer, he should be allowed to correspond *directly* with the battery officers who have charge of the range-finders.

Against this, it may be urged that when the extreme simplicity of the range-finders is fully recognized, these precautions will appear superfluous, nevertheless, if followed in part, or altogether, they will facilitate matters.

This officer should get an instrument maker to take to pieces one set of range-finders, in order that he may become thoroughly acquainted with its construction.

The second he should use to practice "adjustments" upon.

The use of the other two will be as reserves.

In some of the batteries a trifling accident will happen to a range-finder, which probably could be rectified by a shoeing smith in half-an-hour. The battery commander will report this to the officer told off for the special duty, who will send him a reserve range-finder, and receive back the other one; he will then ascertain what is the injury, and make it good, and give instructions how to repair, and avoid a similar injury for the future.

It may here be said that unless the wires break (and these never *are* injured), or the glasses are cracked, a blacksmith will be able to effect any repairs rendered necessary.

It is not at all necessary that the battery officers should understand the interior of the range-finders, but certainly one officer in the artillery should do so.

The 12 sets of range-finders should be divided between horse artillery, field batteries, batteries of position, gatling or mitrailleuse batteries, and mountain batteries.

When the *V's* are fitted on, the special officer should take a pair of each guns, in order to place the gun mark on the H line of the top of the rollers, this mark varies for each description of gun, but is constant for all guns of the same description (provided that the distance from the rear *V* to the muzzle is kept the same in all guns of the same class). The officer takes a pair of guns, draws them up about 40 yds. apart, so that a line joining the breeches of the two guns is *nearly* perpendicular to their line of fire.

Both guns having the angle-finders placed on them, and the cross wires of the main telescopes are laid on the same object, which should not be less than 1000 yds. distant. Then the short telescope of the right angle-finder is laid carefully on the white face of the other angle-finder, and the number (x) given by the index noted. The short telescope of the right gun is now laid on the muzzle of the left gun, and the index number (y) is noted. Subtract this last number from the first, and we have

$$(x - y) = z. \quad \text{or } (x + 100 - y) = z \text{ if } y \text{ be greater than } x.$$

Set the tape arrow on line E, to the distance between the guns—that is the actual measured distance, say $41\frac{1}{4}$ yds., and opposite the number $(x - y)$ or z on G. Make a scratch on the top surface of the roller.

Now place the guns about 55 yds. apart, and repeat the operation as before, getting x' y' for index numbers; it will now be found that when the tape mark is set to the true distance between the guns, say $55\frac{1}{2}$ yds., that the scratch previously made ought to come exactly opposite $x' - y'$ on line G, if this is the case, the operation has been correctly performed. Make a mark in the shape of a gun at the scratch, and, to prevent future confusion, write over this scratch the nature of the gun, as—9-pr. R.M.L.

Precautions to be observed.

The distance between the guns is to be measured in this operation from the axis of one main telescope to the axis of the other main telescope.

Let the distance between the guns be always at least twenty times the distance between the centre of the white face of the angle-finder and the muzzle of the gun. When, however, the theory of the mechanical calculator, as described later on, is thoroughly understood, this last rule need not be followed.

One roller having been marked for a particular description of gun the other rollers are taken; the tape-mark is set at 50, and each roller is then marked with the gun-mark on the inner top ring, opposite to the same number on G, that the gun-mark on the specimen roller, first operated upon, points to; the rollers being thus complete, if the common tape, such as is usually sold in round cases, is employed, the distance between the guns should be measured from like part to like (say from handspike to handspike), when the range is being found; if one of my peculiar tapes, terminated by a hook, is employed, from *inner* trail-handle to inner trail-handle is the best; this will require the tape to be shortened about 15 inches, to allow for the projections of the handles.

It is now supposed that a battery is furnished with two sets of range-finders, placed on guns 1, 3, 4 and 6, and that it is required to instruct the men in the use of the range-finders.

Before doing so, it would be of the greatest use to peg out a measured range. To effect this, let an officer select ground over which a battery, or at least two guns, can manœuvre for about 500 yards. Let him then very carefully, with the instruments, and with large and varying bases, get the distance of an object, distant say 1500 yds., then let him peg out a range 1500, 1550, 1600, 1650, &c., for 500 yds.

At drill he will move his battery up and down this range, showing to his men that they have got the range 5, 10, or 50 yds. wrong.

Ordinary method of obtaining the Range.

The battery is supposed to have 6 guns, of which Nos. 1 and 3 have one pair of range-finders, Nos. 4 and 6 being provided with another pair; it is advancing in line at a walk, and the officer commanding wishes to come into action.

He places himself between 3 and 4 guns, and guides them into a good position, he then gives the word—

"Range on the hedge, near the top of the hill. Halt! Action."—

Nos. 3, 4, 2 and 5 guns are unlimbered; No. 2 is placed so that it will be in front of the line from 3 to 1; No. 1 and 6 guns are not unlimbered. The sergeant of No. 3 chooses any point that he thinks remarkable in the hedge, say a poplar tree, and lays on it with his ordinary sights; when his gun is laid very roughly in the direction of the object, he shouts out "Forward;" this word should be given within 5 or 10 seconds of the command "Halt," and a sharp sergeant will often have his gun sufficiently well laid (or rather brought into line) to be able to give this signal before the trail touches the ground.

The sergeant of No. 3 gun then continues to lay his gun, with the ordinary sights, and finally finishes the laying with the telescopic sight of the angle-finder. He then runs to No. 1 gun, and lays that gun upon the same point, and then returns to his own piece.

Immediately on No. 3 gun being unlimbered, a man takes out the tape and runs with it to the other (No. 1) gun; he should see that the man with the roller gets the true distance between the guns, he then winds up the tape and replaces it.

A third man at No. 3 takes out the angle-finder, places it in its *V's*, and directs the short telescope on the white face of the other angle-finder. When he sees that the sergeant of No. 3 gun has finished laying No. 1 gun, he gives the word "read." He sees that the tens are correctly read; he then waits until he sees the short telescope of No. 1 gun has been pointed at No. 3 gun, and then replaces the angle-finder in the box.

The sergeant of No. 1 gun has kept his gun limbered, and a good deal—say 15 yards—in rear of where he expects it will be placed; he runs out and takes up a good position for his gun, selecting a place where he can get a good view of the hedge on which the range is to be taken, and also keeping himself square with the wheels of No. 3, that is, so that these two wheels appear as one.

On the word "Forward," No. 1 gun advances and is unlimbered when its axle-tree reaches the sergeant, who then lays his gun, resigning his place *promptly* to the sergeant of No. 3 when he comes up; he subsequently sees that the roller is worked right.

The angle-finder is similarly treated to that of No. 3 gun, but, in addition, a man uses the calculating roller, and calls out the range.

A fourth man, both at No. 3 gun and No. 1, reads the number given by the index. In calling out this number the man at the pivot gun must look at the roller gunner; he must satisfy himself that the roller gunner has distinctly heard this number, and must not consider he has done his work because he has merely cried out the number.

At the outer gun (where the roller is used), the man obtaining the index number gives it in a low voice to the roller gunner, when he clearly perceives that the roller gunner is ready for it.

Meanwhile the detachments of Nos. 4 and 6 guns have done the same. A subaltern officer glances over 3 and 4 guns to see the points they have taken; he will then probably know the ranges of two points in the hedge.

Remarks on the above process.

Numbers should be shouted aloud in the right half battery, except the index number found at No. 3 gun; there is no necessity for shouting at No. 1 gun, as the man with the roller is near.

Each man who finds an index or tape number, must see that the roller gunner gets the correct number; the officer should insist upon this point.

One man at each gun reads the angle-finder, but another should check him in the tens; that is to say, should see that the tens are rightly given.

For example, the index number is $47\frac{1}{2}$, a man should see that the forty is right, the $7\frac{1}{2}$ is sure to be right, and should not be checked, as otherwise attention is directed from the tens.

The checkers grow careless as there are few mistakes, but the officers should always see that they attend to this point. No mistakes are ever made in the units.

If the bar has been screwed much to one side in the operation, this ought to be rectified before replacing the instruments. If the tape breaks no harm is done, knotting it will not sensibly affect the range.

The chief amount of skill is demanded of the sergeant of No. 3 gun, the work of the other gunners being mechanical and uniform. In selecting his point, he must choose one that can easily be distinguished, *both* with the naked eye and in the telescope, from contiguous objects; if he can find no such point with his eye, then he must search for one with the telescope.

In running to the outer gun he should keep in view his selected point. If this is hidden from him at No. 1 gun, he has two courses open to him.

1st—To shift No. 1 gun further or nearer, until he can distinguish his point from it.

2nd—To choose a new point, then to lay No. 1 gun on this, and afterwards to alter the laying of No. 3 gun to this point.

In laying, the sergeant of the gun should not allow his wires to be more than three inches on one side of the selected point, or more than three feet above or below it: that is, his lateral error should not be greater than three inches, his vertical than three feet.

To know which is the *pivot* gun.

If the battery is in line, and if *two* sets of instruments are used, 3 and 4 will be the pivot guns.

If one set only, then the pivot gun, for range-finding, will be that nearest the pivot flank for ordinary drill of the battery.

In column of half-batteries the drill pivot is also the pivot for range-finding.

In deploying, or forming line for action from other columns, the gun that comes up first into action becomes the pivot.

Use of the Roller in taking the Range.

The ordinary straightforward method of taking the range is when the range is considerable, and more than 25 times the distance between the guns, and when a tape is used.

Instructions for Calculating Range with Roller.

(1) *Set the tape arrow, on line* E, *to whatever number on line* F *the tape measures.*

(2) *Set the mark, on line* C *(in the shape of the breech of a gun), to the index number called out at either gun.*

(3) *Note on the large red figures, on line* C, *the index number given at the other gun, over this is a number on line* D; *above the corresponding number, on line* E, *will be found on line* F *the range.*

It is extremely improbable that in a campaign a gunner will require any knowledge of the roller beyond the above: there are, however, some secondary uses of the roller.

Secondary Uses of the Roller.

To determine a range when the range *may possibly be less* than 25 times as great as the distance between the guns.

Suppose the guns are 90 yds. apart, it will be easily comprehended that the word tape must be brought under 900, as there is no 90 on the roller.

Let us, in addition, suppose that our gun numbers are 30 and 20.

According to our rule, if we set the breech of the gun at 30, over 20, on line C, we find 50 on it, and over 50 on E, we find a range of 4,120 yds., which may be quite right.

But suppose that the range does not appear to be nearly 4,120, can we have another range corresponding to 50?

Yes.

Below the 0, on E, we see the figures 9, 8, &c.; these really mean 90, 80, &c.; and we shall find over the 5 or 50, 1,378, which may be the true range.

Can there be another true range?

Yes.

Counting back 10 divisions from 5, we come to a number marked 75, but which might also be considered 50; over this is a range of 824 yards.

There are, then, three possible true ranges, 4,120, 1,378, 824, and, indeed, there are several other true ranges, all smaller than 824.

The question will arise, "Does not this lead to uncertainty in the ranges?"

Practically, No: because the finders will be chiefly used between 1,000 and 4,000 yards; and if a distance of about 40 yards be kept between the guns, there can, within these limits, be no ambiguity.

Occasionally, to insure greater accuracy, large bases of 90 yards may be employed; the gunner is then liable to the above ambiguity, but the

difference between the two possible ranges is always too great to allow of a doubt; should, however, any uncertainty exist, a second observation, with a *different* distance between the guns, will dispel the ambiguity, as the real answers, in both cases, would be the *only* ones agreeing.

Beyond the first, or straightforward case, this is the only point in the roller which it is necessary that the gunner should know; as the case will, however, occasionally arise, it is well to say a few words on this head.

Where rapidity is required, the guns will generally be kept at one drill interval, 19 yards apart; or at two, 38 yards apart; in either case a few extra yards may be stolen by an officer wishing to have accurate ranges.

The instruments are quite capable of giving the range with a 19 yards interval, or base, up to 2,000 yards; yet it does not pay to make this the ordinary base, because the extra care required in the manipulation more than makes up for the disadvantages of the larger base.

At a 19 yds. interval, or base, it is clear that the first special or small number case will not arise, as artillery do not care to measure ranges of less than 500 yds.

In trying for a 38 yds. base, the guns may, after coming to the ground, find themselves as much as 50 yds. apart; in this instance, the first special or small number case may arise, as, with a 50 yds. base, anything under 1150 will fall in the small numbers, and 1100 yds. is an artillery range.

Now, in this instance, if a gunner sees that the enemy are from 800 yds. to 1500 from him, and that the interval between the range-guns is considerable, he ought to be on the look out for the small numbers. Suppose, first, that the sum of the two index angles, as found by the roller, or as mentally added together, equal 10 or 20, the gunner knows at once that he is dealing with the ordinary case, because 10 and 20 on line E will, in the ordinary course, give ranges of 1140 and 1340, which are between the limits 800 and 1500, while 10 or 20 in the low numbers would give ranges of 600 or 635, which the gunner's eyes assure him would be an improbable answer.

If, on the other hand, the sum of the index angles should be 70 or 80, then the gunner knows at once that he has to seek for the range (in the instance specified, among the low numbers), because 70 and 80 will, in the low numbers, give ranges of 880 and 755 yds., while in the ordinary numbers they would give the impossible ranges of 3700 and 5700.

To Test the Tape.

The tape is liable to injury; as a rule, however, if the tape be set right for a length of 40 yds., that is, if when the axis of the angle-finders are, say, 41 yds. apart, the tape be made also to read 41, then it will be sufficiently right all through its length.

To Correct the Tape.

Place the guns about 40 yds. apart, laid upon an object, the guns to be square with each other.

Lay the short telescope on the white face of the opposite angle-finder, we thus get an index number (m); set the breech of the gun, on line C, to this number on D.

Lay the short telescope onthe muzzle of the opposite gun, note the index number n on line A or B of the roller; take n over this on B or A, we thus get a number p. Now set the mark (made) on H to the large figures, giving p on line G. Then the tape mark will point to the *true* distance between the guns.

Measure the distance with the tape, and if it does not agree with the *true* distance, shorten or lengthen the tape until it does.

NOTE.—It is evident $p = m - n$, or else $p = m + 100 - n$.

NOTE.— If the guns are placed nearer the 40 yds., the mark on H may have to be set to the smaller figures on G, and not to the large ones.

To obtain the Range without using the Tape.

Be particular in bringing up the guns to see that they are more than usually square, proceed as usual at the pivot gun, only do not run out the tape, also do not call out the index number until the roller gunner shows by a sign that he requires it.

At the outer gun, take the index number as usual, and record it as usual on the roller, by bringing the breech mark on C, under the index number on D.

Then direct the wires of the short telescope until these are on the muzzle of the opposite gun, make this the "muzzle-number" now shown by the index.

Seek the muzzle number on lines A or B (no matter which), opposite to it, on B or A will be "the muzzle difference number." Set the gun mark on H to the muzzle difference number on G.

Now get the index number from the pivot number, and proceed as usual, that is:—

Note on C (the red figures) this number over it, on D is another number, follow this up to E, and above this figure on E is the range.

This is strictly true, if the guns are less than 110, or more than 34 yds. apart; if they are nearer than 34 yds., and if the muzzle difference number is, say, 60, the gun mark on the line H may not have to be set to 60 on the line G, but to the division marked 6.

The fact is that there are several 60's on the flat face of the roller, but only that usually employed is marked 60, the others are marked 6.

As long as the guns are over 40 yards apart, there can be no doubt; in this case the gunner sets the gun mark on line H to the numbers running from 40 to 30, which are marked *in full*. If the distance between the guns is less than 40 yds., the gunner can tell which is the right number, say 50 or 5, by observing how far the guns are apart, and remembering that if the muzzle difference is *properly* set, the tape mark *must* also point to the actual distance between the guns.

Figuring of the Roller.

Lines A, B, C, and D, are each simply divided into 100 equal parts.

Line E, commencing at 0, is marked 10, 20, 30, 40, 50, 60, 70, 80; beyond 80 will be seen 1, 2, 3, 4, 5, 6, 7, 8, 9, which mean 81, 82, &c., 89; we then come to the 0 at which we set out, and this *may* mean 90;

the 10 to the right of 0 *may* mean 91; 20 *may* mean 92. These meanings are, however, of little practical importance, as, with a base of 50 yds., 90 on E would give a range of 11,400 yds., which is not an artillery range.

Let us now start again from 0, but try back to the *left,* we see 9, this means 90 among *the small numbers,* 8 means 80, 7 70, &c., and 80 will mean 0 *among the small numbers.*

TABLE.—*Showing probable and possible values of particular figures on line* E, *presuming that the values in the first column are the only probable values.*

Figure on Roller.	Probable.		Possible.	
	Sum of Base angles of triangle.	Vertical angle of triangle.	Sum of Base angles of triangle.	Vertical angle of triangle.
0	$177\frac{1}{2}°$	$2\frac{1}{2}°$	$179\frac{3}{4}°$	$\frac{1}{4}°$
20	178°	2°	179°-48′	12′
60	179°	1°	179°-54′	6′
80	$177\frac{1}{2}°$	$2\frac{1}{2}°$	175°	5°
9 to the left of 0.	$177\frac{1}{4}°$	$2\frac{3}{4}°$	$179°\text{-}43\frac{1}{2}′$	$16\frac{1}{2}′$
5 to the left of 0.	$176\frac{1}{4}°$	$3\frac{3}{4}°$	$179°\text{-}37\frac{1}{2}′$	$22\frac{1}{2}′$

TESTS.

The instruments scarcely ever lose their original set; when, however, it is considered how much will depend in action upon their absolute accuracy, it will be seen how necessary it is to provide tests which will always assure the officers of a battery that the range-finders will give the exact distance.

Sun Tests.

For an hour and a half after sunrise, or before sunset, this may be used without digging holes for the trails. The two guns are laid by their sights on the sun; the object glasses are covered with shutters so as only to leave a small hole through which the rays of the sun can enter; the size of the hole varies with the brightness of the sun, the smaller the safer, if the sun be distinctly visible.

The reason for putting on the shutter is simply that the object glasses of the telescope are burning glasses, and if the full heat of a bright sun were allowed to enter it might, in some cases, spoil the test, and possibly destroy the wires, although this last has never yet happened.

For the same reason a man should cover the object glass with his hand whenever the telescope is not actually being looked through.

A glass shade is also put over the eye-piece or near end of the telescope.

Enough light should be found in the telescope to see the wires distinctly when *off* the sun; if this cannot be done the shutter of the

object-glass requires opening; the wires can always be seen when *on* the sun.

The wires are laid on the sun so that the horizontal wire splits the sun, while the vertical wire touches its right edge.

This being done at both guns, the observers follow the sun with the screws of the piece, calling "on."

The officer halts them both at the same moment. The cross telescopes are then laid upon each other as usual, and the numbers recorded; this is, say, five times repeated; then the observers are interchanged (to get rid of any personal error) and five more observations taken.

The totals of the 10 observations are added together and divided by 10, and the result should theoretically amount to 100 (or better, practically, 99⅞).

On the word "halt," each observer should throw up the hand on the traversing screw; the officer should also ask both if the observation was good, and omit all bad observations.

This test can be made in a quarter of an hour, and is then infallible; one good observation takes about two minutes. The moon may also be used without shutters or glasses for the same purpose.

The coloured glasses must on no account be placed over the object glasses, as then all the embarrassments of unequal refraction would be introduced.

The guns may be at any distance apart; 40 yards for choice.

If the shutters are lost, a piece of paper with a hole might be substituted.

The Four Angle Test.

Choose two distant points roughly, at right angles to each other, A and B. Lay either gun (the left) on one point A, then dress the second gun on B, about 45 yds. from the first gun. 2,000 yds. is a good distance for A; 900 for B.

The guns will be dressed, when both being laid on A, the centre of the white of the right instrument is seen just under B, looking through the short telescope of the left gun.

Take a pair of angles as usual, say 43 and 52 are the gun numbers, now, lay the short telescope of the left gun on B; its angle (or gun number) is, say, 42. Shift the left finder to the right gun, lay its telescopes on A and B, the new angle is, say, 4.

Write down these numbers as below, subtract 42 from 4, adding 100 to the 4 if smaller than the 42, but not otherwise.

$$\begin{array}{rr} & 4 \\ & 42 \\ \hline \text{Result} & 62 \end{array}$$

Add 62 to the ordinary observations, 43 and 52.

$$\begin{array}{rr} & 43 \\ & 52 \\ & 62 \\ \hline \text{Second result} & 157 \end{array}$$

Cut off the 100, or if there is 200 in the answer, cut off the 200.
Final result 57.

Therefore the instruments read 57 too high or 43 too low.

When the instruments are in order the second result should be 100 or 200.

In this last test it may be as well to point out that there is a *slight* error if the point in front be near, that is, if the point be distant 2,000 yards, instruments which apparently add up to 100, will, in reality, add up to $100\frac{1}{8}$; if the point be distant 1,000 yards, then, while they apparently add up to 100, they will really be set at $100\frac{1}{4}$.

The sun test is mathematically true. If the instruments are set exactly at 100, we are, in measuring a distance of 2,000 yards, liable to a plus error equal to a division of $\frac{1}{8}$, at 1000 to a plus error of $\frac{1}{4}$.

If the bar is in the centre of the divided plate, when the distance of an object is being taken, or within one quarter of the whole divided plate from the centre point, the obliquity of the triangle practically introduces no error; the bar need only be looked at to ascertain this.

As a *rough* test, the range of the same object may be taken with two widely different bases, as 30 and 60 yards; if the answers agree, the instruments must be in order.

The result of each *careful* test should be written inside the lid of the box, with the date and name of the worker; this will provide a history of the instrument.

Instruments testing between $97\frac{1}{2}$ and 100 are in good condition, but they should never be allowed to test too high.

Manner of inscribing Tests on Box.

Tested 10th Jan., 1870, $97\frac{3}{4}$. Lieut. A.
„ by Sun, 7th Nov. 1870, $97\frac{5}{8}$. Captain B.
„ 7th July, 1871, $97\frac{3}{4}$. Captain B.

To Correct a Pair of Instruments.

Let us suppose that we have, by the above tests, discovered that a pair of instruments read 5 too much.

How is this 5 to be corrected? If in a great hurry, the gun mark of the roller may be scratched out, and a new one made 5 below (at 95). The tape must always be used if this has been done.* It is a bad but a ready plan; the answers are perfectly accurate.

The second system of correction takes more time, but is infinitely better, not in accuracy, but in simplicity. The instruments read 5 too high, we want to make them read 5 lower.

Choose two distant objects tolerably square with one another.

Lay the telescopes of one instrument on both. Write down the gun number, say, $47\frac{1}{2}$.

If we could make the instruments now read $42\frac{1}{2}$, they would be correct.

To effect this—

Take off the case.

* That is, observations must not be taken on the muzzle.

Take off the limb with the short telescope attached to it. Place the flat of the limb against the tire of the wheel, and hammer with three or four sharp taps of the hammer the side opposite to that which you want the arrow to go.

Remember, it is not the EDGE of the limb, but the FLAT part you are to hammer—about one-third of the limb's length from the index.

Try not to bend the limb up or down in hammering; if it is bent, it can be set right with two pincers. Put on the limb; observe the points —gun number is 41.

The correction has been overdone; hammer the other side, until $42\frac{1}{2}$ is given.

N.B.—This operation will probably not be required once in three years.

To ascertain the Range with only one Finder.

Select your object and choose another square—(that is roughly at right angles)—to it. Lay on the observed object.

Unlimber a second gun between the first one and the square object, dress its rear V, or better, the place where the centre of the white face of a finder would be on the square object.

Lay this gun.

Then, successively point in each gun the main telescope of the instrument on the observed object, the short on the square object; note the gun numbers thus given; measure the distance between the guns.

Set the tape on the roller as usual. From the gun number of the gun furthest from the square object, take the gun number of the gun nearest to the square object.

Over the number so obtained is the range.

Example: Distance between guns, 50.

Gun number furthest from square object, 67.

Gun number nearest square object, 6.

$$\begin{array}{r} 67 \\ 6 \\ \hline 61 \end{array}$$

Over 61 on line E will be found the range 2945.

If wished, the subtraction can be performed by the lower flat face of the roller.

DRILL FOR 12-PR. B.L., 9 AND 16-PR. M.L. GUNS.

Pivot Guns.

No. 1 lays the gun by its ordinary sights (the tangent scale being at point blank for all guns except the 12-pr. B.L., when it should have elevation for 1000 yards).

When the gun is *roughly* laid, he gives the word "Forward," then he lays the right edge of the vertical cross-wire on the object, he then runs to the outer gun, and lays it likewise.

No. 2 assists to traverse gun and reads.

No. 3 runs out tape.

No. 4 traverses.

No. 5 places angle finder on *V's*, works short telescope and sees that No. 2 reads the *tens* correctly; replaces finder when the No. 5 at the outer gun no longer wants it.

Outer Gun.

No. 1 keeps his gun *well* to *the rear*, so that it may, on the word "Forward," come up to the right position without reversing.

Posts himself square with the wheels of the pivot gun.

At the word "Forward" the gun is brought up *between* him and the pivot gun, the wheels being thus square with those of the pivot gun.

No. 1 does not aid in unlimbering, he lays his gun, but *immediately* cedes his place to the No. 1 of the pivot gun.

He then sees that the roller is correctly worked, and that the Nos. 5 check the readings (from the tens) of the Nos. 3.

3 uses roller.

2, 4, 5, as at pivot gun.

To find the range of a moving object.

A moving object is one that *can* move, whether at the moment stationary or not; it includes men, horses, guns and wagons.

In finding the range of troops, right and left will mean our own right and left, and will be irrespective of the front of the enemy.

In this case No. 1 of the pivot gun does not quit his gun. Both Nos. 1 lay their guns on the designated object, following it with the traversing screws. As the chief point is to be quite certain that both guns are trained on the same object, either of the Nos. 1 will describe to the other anything peculiar in the man or gun layed on, as—

"The horse has two white stockings and is switching its tail; the man is an officer and has a paper in his hand." Or—

"The gun has just fired, the men are running it up, and the man on the left has his arm stretched out."

Both Nos. 1 follow the moving object, calling "on" every two seconds; when both together call "on," the officer calls "Halt," the operation is then concluded as with a stationary object.

The distance found is that of the object at the moment halt is called.

If the guns are inverted at drill, and the right instrument is found to be on the left, and the left on the right, then the word "change finders" should be given, and the Nos. 5 should change the instruments.

Care of the Instrument.

The screws of the case, or of the tangent screw handle, may always be loosened or tightened without affecting the setting of the instrument.

After a day's work the twist should be taken out of the tape.

The hasp securing the lid of the box should be turned during travelling or firing.

If a drop of rain gets on the eye-piece, the cap can be screwed off and the moisture removed.

Description of the various Parts of the Range-Finder.

This description being given solely with a view to effect any repairs that may become necessary in the range-finder, the reader is supposed to have in his possession a set of the instruments.

The angle-finder may be considered to have two sets of parts essentially different, namely, those on which the *accuracy* of the angles depend, and those which are merely used for convenience.

The first comprise *only* the object glasses and the wires. The second include the eye-pieces, the case to protect the short telescope, the tangent screw, &c.

Many people attribute equal importance to all portions of the instruments, and if the limb fits loosely, or if the exterior screws shake, think that the angles may be affected. This is erroneous; every single screw that can be seen from the outside of the instrument could be removed without the accuracy being at all impaired.

Wire Piece of the Large Telescope.

This is composed of a stout cylinder, a small moveable plate, and platinum, or gold wire.

The screws fastening the wires are keepered, that is, smaller screws are driven through them.

The wire plate is fastened to the wire cylinder by two keepered screws.

There are two additional screws which appear also to fasten the wire plate, but these are only partly used for this object, as they have play, their real purpose is to aid in the collimation.

There are two side screws extending from the wire piece to the outside of the instrument, these are only used for focussing.

The wires of the main telescopes have never yet been broken or injured.

Should this happen, if an *instrument maker* performs the repair, he should remove the object-glass and eye-piece, remove the screws fastening the wire piece, and force the wire piece out by ramming a stick in at the object-glass side, he will put on new wires, and if these are found not to be in collimation, he must collimate that is, bring the wires exactly in the axis of the telescope, by shifting, tentatively, the collimating plate.

If the wires are injured on service,

Proceed to remove the wire-piece as above.

If a bit of a surveyor, let the officer put on the cobweb of a field-spider instead of wires; if he does not understand this operation, let him twist unspun silk, a very thin fibre of tow, or any other thin fibre, round the screws, securing the ends with sealing wax. He should not attempt to regulate the collimation, but refasten the wire-piece; the observations (after testing) will be perfectly accurate, although the instruments will not be as convenient to use with unskilled men.

Object Glass.

The object-glass, that is the large glass of the main telescope, has not, to my knowledge, become shaky in any instrument during the last two years.

A shake will be detected by pressing the fore-finger lightly on the glass and endeavouring to move it. The amount of inaccuracy which a shake is liable to produce can be detected by taking observations when the object glass is pushed into two extreme positions.

To correct a Shake.

An instrument maker will re-burnish the glass. *On service,* the officer should remove the screws holding the glass, he should then screw out the glass and its case, either by the nicks on it or by pressing the handle of a turnscrew against the sides of the case.

He should then take a turnscrew, and with its blunt side squeeze down tightly the brass rim binding the glass, or rather the three glasses, running the blunt edge of the turnscrew round and round this rim strongly until the glass shakes no more.

He should then screw the glass and case into the instrument as tightly as he can, and bore *new* screw holes, and insert the screws in them.

Object Glass getting dim.

In nine cases out of ten when this happens, it is really not the fault of the object glass, but of the eye-piece.

Remedy.

Take out the eye-piece and see if, in any position, it will give a clear image, if not, some of the internal glasses of the eye-piece may have slipped; shift them, and see if a clear image can thus be got; as it is impossible to do any harm, even to the adjustment, by fiddling with the eye-piece, this may freely be done. If wiping or changing the position of the eye-piece makes the telescope clear, bind the eye-piece in the best position. If the object-glass is dim, and it is not the fault of the eye-piece, screw out the object-glass; if there is dirt or moisture on the inside of the glass, wipe it off; if there is none, hold it up to the light; if the glass then looks clear, a mistake has been made, and the eye-piece is the real culprit; if, however, it is still very dim, moisture has got in between the three glasses, the brass rim must be raised up with the sharp end of a chisel, the glasses removed, cleaned, and the brass edge forced tightly down.

All the above remarks apply also to the short telescope, save that the wires of this never require collimation.

In conclusion, my advice to an officer, out of reach of an instrument maker, or of spare parts of instruments, would be this:

Do anything you like with the eye-piece, even if you smash some of its glass, remove the broken parts and probably it will work without them (sometimes another glass as well as the broken one has to be removed).

Never interfere with the wire pieces if possible.

If there is a shake in the object glass, remove and correct it; but first be quite sure that the shake is not in your own fancy.

A real shake will affect the observations; it will be also, when the forefinger is applied, not only felt, but heard to make a perceptible click.

Do not remove the object glass for dimness, unless the instruments are unworkable.

Out of 10 sets of instruments probably not more than one will suffer from any of these evils in three years.

Non-Essential Parts.

The eye-pieces do not affect the adjustment; it has been already explained, under the head of object glasses, how any damages to these should be repaired.

White Discs of Paper.

In replacing these, care should be taken that the centre of the lower portion of the disc corresponds with the notch marked on the case.

Tangent Screw.

The only real damage that can happen to this is, that it may become stiff; this will be owing to a grain of sand having got into the bearing and scratched it; in this case the screw should be taken off and the bearing filed smooth.

Roller.

New rollers are liable to work very stiffly from moisture in the atmosphere. In this case the rings should be taken off and their inner circumference, or the corresponding outer surface of the roller, scraped with a pen-knife, until the rings turn smoothly.

Tape.

This is the only perishable portion of the instruments. It is more economical to throw all the work on one tape, and to keep the others sound.

The figures on the tape will have to be renewed in the battery every six months; the collar-makers will also have to piece the tape up neatly now and then.

The screws used in the range-finders are all of the Whitworth taps.

Influence of the Range-Finder on Tactics.

No general would, or probably should, modify his tactics for any improvement in weapons without being thoroughly convinced that such an improvement was real; in the case of the range-finder a general should carefully examine for himself (before in the slightest degree he built his combinations on the change) if the superiority claimed for it is substantially correct.

The superiority claimed is an average advantage of 3 to 1 in the destructive effect at ordinary artillery ranges, say from 1,300 to 2,000 yards; and a still higher ratio at long ranges, say from 2,000 to 3,500.

To satisfy himself, the general will simply have to pit one battery, firing by trial shots at targets, against another firing with the aid of the range-finder; the only precaution he need take is to see that those using trial shots work fairly, as there will be an universal desire on the part of the officers and men to supplement the trial shots by various dodges which could not be used on service.

Starting, then, from the assumption that this superiority is real, but fully acknowledging that a commander should verify such assumption by his own *individual* experience, the modifications which may be thus introduced into tactics will be briefly weighed.

Grand Tactics.

Three cases present themselves: an army acting on the defensive with range-finders may combat an opponent without these instruments.

An army on the offensive may be supplied with range-finders, its antagonist having none.

Both armies may have range-finders.

Defenders only provided with Range-finders.

In the first instance, in choosing a position, more advantage will be given to one which commands the approach of the enemy, up to 3000 yds., than at present.

All roads, bridges, and streams, which delay the enemy under fire, within 3000 yds., may be considered nearly impassable when exposed to the fire of guns at ranges accurately known. It may also be assumed that the enemy will never be able to overpower the artillery fire of the defenders; that cavalry will not be able to halt within 2500 yds. of the defenders' guns, and that it will be impossible for the enemy to advance in deep columns within 3000 yds.; further, that the enemy will, even in line, or very thin columns, suffer much more than heretofore.

An Army on the offensive provided with Range-finders, the enemy having none.

In this case, if rapidity of movement is of consequence, one-third of the usual complement of artillery may be dispensed with.

In attacking an intrenched position, it will be remembered that the defenders may have paced the ranges to conspicuous points; if they have *thus* measured the distances roughly, conspicuous points should be avoided in taking up positions for batteries. In any case the defenders' knowledge of the range will probably be partial, inferior at the commencement of the action, and very confused after a time.

The assailant should endeavour to engage the defenders' artillery, being fully confident that he will have a great superiority over it.

When the point selected for an infantry attack has been determined on, it will obviously be much easier to cover this attack by guns which know the exact range, and which may be relied on to cripple the enemy's infantry fire, and to keep it down until the troops are within 200 yds. of the defenders' lines.

In fact, with range-finders, guns will be used rather to co-operate with, than (as at present), to prepare for, the infantry attack.

Both sides having Range-finders.

In this case, the assailant will, more than ever, seek to precede his attack by an artillery duel, as the defenders' guns will not only have increased power of disabling his infantry, if not silenced, but also to inflict on his artillery far greater injuries than at present.

The Minor Tactics of a Battery.

Defensive.

Ten points, varying from 1,000 to 3,500 yds., being selected, one gun is unlimbered near where it will be in action, while another takes in succession suitable positions at a distance of about 45 yds. from the first gun, but at rather greater intervals for the longer ranges.

The officer himself, or a sergeant, will note down the distances on a card. This can be leisurely done in 20 minutes.

When these are taken, they should be re-measured with a greater distance between the guns; where any discrepancies occur the distances should be taken a third time.

Ten points being thus established, if time allows, others may be added, if not, their distances should be guessed, and the guessed distance placed upon a card. Should there be any point immediately in front, or near to which the guns may afterwards be removed, its distance should be taken, so that in an advance or retreat the ranges of some of the original points may be known without fresh observations.

The officer should consider what points the enemy are likely to advance on. The Nos. 1 should copy the card, or at least learn the ranges of the principal points, and the lengths of fuze should be marked opposite the ranges.

If the commander has had abundance of time, he will know certain points under 2,000 yds. almost exactly, while at 4,000 his probable error should be under 50 yds.

If the enemy is advancing in deep formation, masses of columns, or of batteries, the guns should open fire as soon as possible, even at 3,500 yds.

At this distance, when brigades are massed, and are passing over observed points, 20 per cent. of the projectiles ought to strike. It is needless to point out that great care should be exercised in laying the guns, allowing for wind, and levelling the wheels at such ranges.

Upon being fired at, the enemy may be expected to break up into shallower columns, probably not more than two companies deep. When these thin columns *are actually standing around observed points*, they may be fired at up to 2,500 yds., but when in movement, or standing between points, so that there is a probable error of 50 yds. in the range, they ought not to be fired at over 2,000 yds.

If the enemy form line, 1,700 yds. should be the limit of fire.

Very good practice can be made at skirmishers up to 1,500 yds., but skirmishers should only be fired at by artillery when ammunition abounds, as one good shell in a column is worth 20 good shells at skirmishers.

Troops lying down in line may be fired at up to 1,500 yds., but very deliberately. Cavalry in line may be fired on up to 2,000 yds.

It may be assumed that artillery will advance at full interval, and in line; if so, they should be fired on up to 2,500 yds. But once unlimbered, if their horses are sent away, and their guns are at all sheltered by the ground, it will be difficult to do them much harm at distances over 2,000 yds.

In firing at artillery, if it seems probable that little damage is being done by either party, a fresh observation should be taken on one of the wheels of the enemy's guns; generally choose the windward gun to take the range.

About 1,500 to 1,700 yds. would be the most favourable distance to choose in firing at guns, trusting to trial shots, as much under 1,300 there would not be sufficient disparity in the effects produced, and as over 2,000 nothing decisive could be counted on.

In an artillery duel, at 1,700 yds., the range being ascertained to within 50 yds., after making every allowance for hurried laying, &c., at least 4 per cent. of the shell fired ought to be very effective; while, if the range be guessed, not more than about one-half per cent. can be calculated on.

Offensive Tactics.

In acting upon the defensive, the use of a range-finder is very plain sailing, as it enables the ground to be surveyed before the approach of an enemy, and thus gives enormous advantages, without any attendant disadvantages whatsoever. Acting offensively, the disadvantages must be weighed against the advantages.

A range-finder does not possess any great advantages over trial shots up to 1,000 yards, so, up to this range, whenever the delay of half a minute in opening fire is of paramount importance, it is better not to use it.

After 1,300 yards the superiority possessed by pieces firing at a known range is so great, that the distance should then *always* be found. Between 1,000 and 1,300 yards the judgment of the officer in command must be exercised.

The actual finding of the range is a purely mechanical operation, but considerable skill can be shown in the selection of points to be observed.

As the telescopes of the finders are powerful, any point that can be seen through binoculars, or with the naked eye, may in almost any weather be observed, so that it is quite unnecessary to pick out church steeples, or, what might be called fancy points, to train the guns on.

What is wanted is something distinguishable from surrounding objects; any stationary object tolerably different from everything near it is a good point, whether a gate, a stone, or a post; trees, shrubs, or tufts of grass must be made to do when the former class do not exist; they are perfectly good points, if peculiar. When no point can be seen, the officer must simply indicate in a general fashion what distance he wants, as, *e.g.*, the brow of a hill; it then becomes the duty of the No. 1 of the pivot gun to find a point, which he can nearly always do, as the telescope of the finder will reveal peculiarities in the brow which may have escaped the naked eye.

But it may not be possible to find any stationary object near the enemy. In that case the guns must be laid on the enemy.

There is no better object than a gun wheel; the windward, or else the most peculiarly placed gun, should be singled out to lay on; its being fired is of little consequence, unless the smoke hangs very much indeed.

The colours of a regiment or a mounted officer are very good points; if there are none, a flank man should be chosen. These remarks only apply to troops advancing or retiring upon the battery, either directly or at a moderate oblique; if, however, the direction of their march is at right angles to the line of fire of the battery, they will probably interfere with the action of the finders; in this last case, the distance between the guns should be made sixty yards, if possible.

Forty yards is in general the best working distance to keep between the pieces, as at greater distances the guns are not in such thorough

communication. At ranges under 1,000 the guns should be kept under 40 yards apart.

1,000 to 1,600, 40 for choice.
1,600 to 2,000, 50 „ „
2,000 to 2,500, 60 „ „
2,500 to 3,500, 70 „ „

Do not, however, be put out if the guns come into action at a distance different from what is intended, that is of little consequence.

Sloping ground does not impair the accuracy of the range-finder.

The task of the officer is not to find the range, but to place his guns in a favourable position for finding it.

When a battery comes into action, whether with or without range-finders, the Nos. 1 have a most important duty to perform, which is especially prescribed in all drill-books, but which I have invariably found that they omit. It is simply, before unlimbering, to make sure that they can see the enemy they are about to fire on—along their sights.

On rough ground a 12-pounder gun cannot, when unlimbered, be moved far by hand; or, what amounts to the same thing, it is quicker to limber up and again unlimber.

Although in war this point is of equal importance, whether range-finders are used or not, in peace no time is lost if it is forgotten when working without instruments, but a great deal of time may be expended on repairing this error when working with range-finders.

There are two points for a No. 1 to remember :—

1st. When mounted, his eye is 7 feet 6 inches above the ground; when laying his gun, only 3 feet 6 inches.

2nd. That the word "action" from an officer does not simply mean unlimber your gun, but unlimber it where you can use it.

The rawest set of gunners can be taught in a single day to use the range-finders for defensive purposes, or if there is *one* officer or man in the battery who understands the instruments, he can find the ranges without the assistance of any skilled labour, at the rate of about one distance in three minutes.

But to enable gunners to use the range-finders offensively, that is, to be able to race men who are employing the trial shot system, requires some practice.

When the detachments are perfect in the mechanical process of finding the range on easy points, and from easy ground, they must be exercised on difficult points against time.

The best way to do this is to take out the detachments with the Nos. 1 mounted, and for the officer to choose the *least* distinguishable features of the surrounding country to work on, while unfavourable ground is selected for the position of the guns, and time is counted from the word "action" until the range is called out.

The N.C.-officer finding the range, should not be fettered as to the distance between his guns, or as to their placing, as it is supposed the remaining guns of the battery would conform to the range guns.

The distances thus found should, if unknown to the officer, be carefully tested by observations, leisurely taken with large bases, and the men should never be allowed to sacrifice accuracy to rapidity.

In taking the range on sands, from which the tide has receded, the pointing of the guns is affected by the sinking of the wheels; the remedy for this is to take the object as if it were moving; it is not fair to judge of a squad's proficiency by its answers the first time on such very peculiar ground, but when once the men recognise the source of error and make their observations rapidly, the ranges will be as reliable as on land.

Short Account of the Infantry Range-Finder.

The infantry range-finders are worked separately or in pairs; the only difference between the two instruments of a pair is that the positions of the mirrors and of the figuring are respectively inverted.

The infantry range-finder may be made to work independently of a musket, but the description given is that of a range-finder adapted to the stock of a Snider rifle; it consists of a sextant and of a mechanical calculator; the sextant fits on one side of the stock of the rifle, the calculator on the other. The sextant does not resemble the ordinary pocket sextant; it consists of a stout steel plate, about seven inches long, and two wide, to which is screwed a mirror; on this plate a tangent screw moves a steel limb with a second mirror attached.

The sextant plate is fastened to a stock, recessed for the purpose, by hinges, and shuts snuff-box fashion, making no change in the shape of the stock when not in use.

The observer receives the base in paces, but gives the answer in yds.

A tape graduated in paces and a pair of rifles will give the range in less than half the time occupied by a single rifle.

The infantry range-finder has been tried before two committees. The first was held in November, 1870, and consisted of Major Kirk, 91st Highlanders; Captain Chapman, Deputy-Instructor of Musketry; Lieutenant Creagh, 42nd Highlanders.

The chief trial in this case was a match between the instruments (worked by private soldiers), against six picked judges of distance, at ranges varying from 500 to 1,000 yds., the distances being taken on infantry soldiers.

Correct distance - -	980	790	600	505	935	830	745	590
Error of Range-finder - -	40	5	12	13	5	10	30	20
,, Private Spillman -	20	50	20	65	5	50	115	20
,, ,, Read - -	40	10	100	145	5	130	95	80
,, ,, Campbell -	80	90	100	125	35	80	95	10
,, ,, Huggin -	90	40	80	15	65	60	25	50
,, ,, Hammill -	80	40	100	115	45	70	35	10
,, ,, McDonald	0	50	80	145	35	10	5	40

At Woolwich, in July, 1871, the infantry range-finder was tried before a committee, consisting of Colonel Wray, C.B., Royal Artillery; Captain Glynn, Rifle Brigade; Captain Fryer, Rifle Brigade; Captain Noble, Royal Artillery; Captain Rawling, 48th Regiment.

The judging party in this case did badly, because they had to guess on fixed points instead of on men, to whose uniforms they were accustomed; their errors at 9 ranges were, 0, 20, 40, 45, 52, 70, 116, 150, 275. The average error of the range-finder was under 15 yds.

A new class of trial was here introduced, viz. firing at a wooden target, 18 × 6 ft., at various distances.

Four marksmen of the Rifle Brigade, judging their own distance, were pitted against 4 men of the same regiment (not all marksmen), who used the range-finder.

In the first 4 trials the men advanced on the targets, in the last three they retired, the result being that the men naturally judged much better retiring than advancing.

	4 Marks-men.	4 Capt. Nolan's Party.	Remarks.
1st trial. About 900 yards.	1 hit	5 hits.	Remainder over target. Some short, some over.
2nd trial. About 800 yards.	1 hit	4 hits.	Remainder all over. Some over and two short.
3rd trial. About 650 yards.	0	14 hits	All over. Remainder close to target, left target fell down, prop knocked away.
4th trial. About 550 yards.	2 hits	16 hits	Remainder over. Remainder round target.
5th trial. About 750 yards.	6 hits	15 hits	Remainder over. Remainder short and close in front of target.
6th trial. About 850 yards.	3 hits	7 hits	Remainder over. Too high. Remainder close in front of target, and to right.
7th trial. About 700 yards.	1 hit	2 hits	Remainder over, very much to right. Remainder about 20 yards short.
Total Hits...	14	63	

The infantry range-finder has only about one-tenth the accuracy of that used for artillery. Still a single rifle altered to take it would permit a company to know its ranges in any defensive position — as Infantry pace pretty accurately no fresh article of equipment need necessarily be carried—its use can be learned by any man who knows how to read figures; its insertion weakens the toe of the butt of the rifle, but still leaves that portion stronger than the small of the stock, the present weakest point; an extra $1\frac{1}{2}$ lbs. has to be carried, but there is no other inconvenience.

A pair of rifles so altered, and the addition of a measuring tape, will permit of the distance being taken with a sufficient rapidity for offensive operations. The instrument is peculiarly adapted to work on broken ground. It must be, however, allowed, that in comparison with the range-finder for artillery, the infantry range-finder is untried.

Rough Table for Practice with Roller.

Tape.	First Angle.	Second Angle.	Range (nearly).
50	40	30	3820
,,	30	10	1910
,,	97	3	1146
,,	90	81½	4000
,,	61	6⅓	3500
,,	9	53	3000
,,	90	69	2800
,,	28	28	2600
,,	41	11	2400
,,	47	1	2200
,,	50	92½	2000
,,	35	4½	1900
,,	40	99½	1900
,,	30	6½	1800
,,	30	2½	1700
100	80	10	22920
,,	61	9	7640
,,	37	3	3820
,,	80	20	2292
25	90	0	5730
25	97	73	1910
,,	35	5	955
,,	0	0	573
On the low figures to the left of the cypher.			
50	80	12	1050
50	70	9½	1440
100	37	3	1430
25	3	37	358

THE MOBILITY OF FIELD ARTILLERY;

PAST AND PRESENT.

BY CAPTAIN HIME, R.A.

[No. IV.]

"Les progrès (de l'artillerie de campagne) ont principalement consisté dans le perfectionnement de sa mobilité."—*Col. Favé.* "*Hist. et Tact. des Trois Armes.*"

When the 19th century dawned upon the world, every civilised nation possessed a light field artillery, which in most cases was well organised and efficient, and in all cases was established upon a permanent footing. Medium and heavy field artillery, however, had almost disappeared from off the face of the earth. Austria, indeed, retained what are commonly called field batteries and batteries of position, but scarcely a vestige of these services remained during peace time in those countries in which light field artillery on the detachment system had been adopted. Medium and heavy field guns and carriages might, it is true, be found hidden away in the obscure corners of arsenals and repositories; but their officers, N.C. officers, gunners, drivers, horses, and harness, were no more, and these batteries existed only in name. The corpse was there—the flesh and bones, the nerves and sinews; but the principle of life was fled, as it seemed for ever.

Had the light field artillery failed on its general introduction throughout Europe, its failure would have demanded a long and elaborate explanation—if, indeed, any explanation were possible. Its success requires none, for every element of success was present at its birth.

In the horse artillery the world saw for the first time batteries endowed with real mobility; batteries in which the three elements of which field artillery consists—the gunners, the guns, and the ammunition—were fused into one complete whole, and brought into action together. The means of draught—the horses and the harness—were excellent, and the mode of draught was good. The men were magnificently dressed, they were amply paid, and they were not haunted by the constant dread of being suddenly and forcibly torn from the field artillery service which they loved, and thrust into the garrison artillery service, which was strange to them and which they hated. Their *esprit de corps*, therefore, was admirable, and they threw themselves with enthusiasm into their special profession. Indeed, at the beginning of the present century the horse artillery was the only field artillery in Europe in time of peace, except in Austria. The horse artillery was the field artillery, and the field artillery was the horse artillery; for the

field batteries were as instable as the sea, as changeable as Proteus. In ancient Rome the temple of Janus was only open, in modern Europe the field batteries were only in existence, in time of war. The fortuitous atoms of which these batteries consisted were attracted and held together by the force of Necessity while the storms of war lasted; but when the sun of peace burst again through the clouds, the spell which had evoked the field batteries was broken, and they silently dissolved into their original elements, which separately disappeared into the hundred garrisons and arsenals from the depths of which they had been called forth.

The collapse of Gribeauval's own artillery—the field batteries—only a few years after his death, was produced by the joint action of three causes:—First, the change of tactics brought about by the French Revolution; secondly, the peculiar organisation of the horse artillery; and thirdly, the disorder and confusion that prevailed in the field batteries themselves, owing to their being organised upon the principle that field and garrison artillery are convertible.

I.—Gribeauval constructed his system with a view to enable his batteries to act with troops moving at the pace of the Prussian infantry.[1] But before men had ceased to mourn for the great reformer's death, the French Revolution burst forth; the formal and respectable tactics of the good old times were cast, as they deserved, to the winds, and a new system of tactics was introduced by the French, which enabled them to conquer almost the whole of Europe. The chief characteristic of the new tactics was the extraordinary mobility they conferred upon the infantry. By radical and extensive changes in its organisation, which it is not my business to describe, this arm was enabled to manœuvre with a rapidity hitherto unknown.[2] An artillery, therefore, constructed with the express intention of supporting the "processional movements"[3] of the Prussian tactics, was plainly unequal to the requirements of the French division, the tactics of which were at once "leste, élastique, et osée."[4] Now, Gribeauval's carriages were heavy; his guns had to be shifted from the travelling to the firing trunnion holes before they could be discharged; the gunners followed the gun on foot, which deprived the system of any little mobility it might otherwise have possessed; the guns were intended to be manœuvred by drag-ropes when under fire;[5] and before limbering up, the guns had to be shifted back from the firing to the travelling trunnion holes. In fine, while the fire of Gribeauval's guns was sufficiently powerful to meet all the demands of the new tactics, the mobility of his batteries was so defective as to render them almost useless in all cases

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[1] "Le but que Gribeauval se proposait, c'était une mobilité assez grande pour pouvoir, dans toute espèce de terrain, suivre les mouvemens d'une infanterie aussi mobile que l'était l'infanterie Prussienne."—Favé, "Hist. et Tact. des Trois Armes," p. 148.

[2] "Die Infanterie wird in einzelne Massen, Bataillone, zerlegt und gewinnt dadurch eine früher nicht geahnte Manövrirfahigkeit und Selbständigkeit."—"Militärische Gedanken und Betrachtungen über den Deutsch-Französischen Krieg, 1870–71." Mainz, 1871, p. 226.

[3] Gen. Trochu, "L'Armée Française en 1867," p. 247.

[4] Ibid. p. 254.

[5] To save the trouble of limbering-up, the prolonge was used for long movements beyond the effective range of the enemy's fire. If every great man has his hobby-horse, surely the drag-rope theory was Gribeauval's.

in which quickness of movement was of importance. It thus became necessary to create a light field artillery capable of manœuvring rapidly, and horse artillery was introduced into the French service. But the light artillery, instead of supplementing the medium, supplanted it; and the rise of the former proved to be the signal of the downfall of the latter. This is not to be wondered at. For four centuries and a half efficacy of fire had exclusively occupied the attention of all soldiers, except two or three men of surpassing genius, and now that the tide of events forced a light field artillery into existence, the value of mobility was fully shown in the field; its importance became universally recognised, the usual reaction took place,[1] and general officers demanded that their divisions should be supported by light field artillery, and by light field artillery only.[2] While the medium guns were seen toiling and struggling after their divisions, far in the distance, the light guns were hurrying from point to point of the field with the speed of lightning; now protecting the hard-pressed infantry, now supporting the wavering cavalry. At one moment they galloped up to canister range, and annihilated the enemy's ponderous columns before they could be deployed; at another they dashed round his flank, and by their unexpected and dreaded fire threw his troops into irretrievable confusion. Then, and only then, might be heard the deeper boom of the medium guns, whose breathless and exhausted gunners had dragged them painfully into position, in time, perhaps, to send a parting shot after the routed and flying enemy. Thus did this splendid service delight men's gaze[3] and overpower their sober judgment, and, like the rising sun—

" . . . . killing the stars and dews,
And dreams and desolations of the night,"[4]

eclipse for a season the lesser light of the medium field artillery.[5]

II.—Time would have lessened, and probably destroyed, the evil influence which the light field artillery thus exercised, indirectly and externally, upon

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[1] Buckle's "History of Civilisation," Vol. V. p. 16. Leipsig Ed.

[2] "L'artillerie à cheval . . . fit des merveilles. . . . Bientôt les généraux ne voulurent plus avoir d'autre artillerie, parceque celle-là étant plus mobile et plus efficace, il en fallait moins, et c'était autant d'allégement dans les colonnes d'attirails."—Gen. Foy, "Hist. de la Guerre de la Péninsule sous Napoleon," Tom. I. p. 119.

[3] "La réputation de l'artillerie à cheval devint de plus en plus brillante; elle attirait tous les regards, et l'admiration générale la plaçait partout au premier rang dans nos armées."—Favé, "Hist. et Tact. des Trois Armes," p. 164.

[4] Swinburne's "Atalanta in Calydon."

[5] "La supériorité que prit l'artillerie à cheval sur l'artillerie à pied, se joignant à l'abandon du service des troupes par beaucoup des bons officiers de l'armée, fit pendant un certain temps baisser l'artillerie à pied."—Favé, "Hist. et Tact. des Trois Armes," p. 166.

"La grande extension donnée à l'artillerie à cheval nuit à l'artillerie à pied . . . . L'histoire de l'artillerie doit relater et étudier avec soin de pareils faits, et cette arme doit s'efforcer d'éviter à l'avenir les mêmes inconvénients."—Ibid. p. 216.

"L'engouement pour les bonnes choses conduit toujours à mal. L'artillerie à pied, énervée par la formation et l'augmentation de l'artillerie à cheval, commença à perdre l'esprit militaire."—Gen. Foy, "Hist. de la Guerre dans la Péninsule sous Napoleon," Tom. I. p. 119. See also "Le Passé et l'Avenir de l'Artillerie," par l'Empereur Napoleon III. Tom. 4. p. 95.

the medium field artillery;[1] and the latter would have regained at all events a part of its former importance ere many years elapsed, had this been the only bar to its progress. But in every country of Europe except Austria, the light field artillery, owing to its peculiar organisation, acted on the medium with far more disastrous effect internally and directly, than it did indirectly and externally. Everywhere but in Austria the light field artillery was a *corps d'élite*, recruited from the artillery at large;[2] and further, it was much better dressed, and somewhat better paid, than the medium field artillery.

Had the light field artillery been a *corps d'élite* in the same sense as the English Guards, its influence on the rest of the regiment would have been one of unmixed good; but unfortunately it was a *corps d'élite* in the same sense as the French Chasseurs à pied, and like all corps organised on such principles, it affected most prejudicially the rest of the arm. The English Guards have the privilege of selecting their recruits and ridding themselves of bad characters under regimental arrangements. The recruits are selected with care, but they are selected from society at large, not from regiments of the line; and the result is that this noble body of men—the Guards—are a source of wholesome emulation, instead of contentious rivalry, to the rest of the army. But the French Chasseurs à pied sucked the heart's blood of the rest of the infantry. Everything that was good, everything that was efficient, everything that was soldierlike in the infantry of the line, was seized upon with unsparing hands, and remorselessly drafted into the Chasseurs à pied. One link of the chain was strengthened, to the detriment of all the others; to fortify one point of the line, the rest was unreasonably weakened; and the natural result was "l'énervation de la masse au profit des groupes."[3] Such a system preys upon its own vitals, and carries within itself the germ of its own destruction:—

> "The young disease that must subdue at length,
> Grows with its growth, and strengthens with its strength."[4]

The more ruthlessly the system of selection is carried out, the more rapidly do the troops from amongst whom the selection is made lose their self-respect, and become at first apathetic, and at last inefficient. The *corps d'élite*, the insatiable parasite, must degenerate in precisely the same degree as the body which feeds it; and the end is, that in the lapse of a few

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[1] I cease to speak of heavy field artillery, because it can hardly be said to exist in the regular artillery service. Notwithstanding the recommendation of the "Committee of Superior Officers of the Royal Artillery," presided over by Sir Richard Dacres, in 1866, the existence of batteries of position is as precarious in 1872 as was that of the field batteries in 1800.

[2] "Chaque bataillon eut une compagnie d'élite qui était de préférence attachée à l'artillerie à cheval."—Favé, "Hist. et Tact. des Trois Armes," p. 217. From the organisation of the Potsdam Horse Artillery Depôt in 1773, it is evident that nothing was farther from the intention of the creator of light field artillery than to make it a *corps d'élite*. "Die Mannschaften wurden von allen Artillerie-Kompagnien gegeben und alle Yahr abgelöst, so dass sich bei eintretender Mobilmachung ein stärker Stamm ausgebildeter Leute vorfand."—Von Troschke, "Die Beziehungen Friedrich des Grossen zu seiner Artillerie," p. 45.

[3] Gen. Trochu.—"L'Armée Française en 1867," p. 203.

[4] Pope's "Essay on Man."

years the whole edifice crumbles, totters, and falls. When the oak falls the ivy that killed it must fall too.[1]

There was no more reason at the beginning of the century than there is now, why the horse artillery should not adopt any uniform that was suitable to the light field artillery service and pleasing to themselves. But there was as little reason why the medium field artillery should not also adopt some dress that was decent and convenient, and befitting their high position as the main body of the field artillery; different though this uniform might be from that of the horse artillery as the night from the day. While the latter, however, were permitted to assume a dress as splendid as were their services, the former were condemned to a uniform and equipment that was at once incongruous and unserviceable; and for many years they presented an appearance that was unseemly, if it was not ridiculous.[2] Had the relations which exist between light and medium field artillery been loose and arbitrary, no difference of clothing or pay could have caused bad effects; but the connection between these services is necessarily of the closest kind.[3] They are flowers of the same plant; they are branches of the same river; and nothing but evil could result from promoting every improvement in the one, and stifling all vitality and progress in the other. A house divided against itself cannot stand.[4]

III.—But with far more baleful effect than either the external influence of the revolutionary tactics, or the internal pressure of the light artillery, did the disorganisation of its *personnel* act upon the medium artillery. The disordered state of the *personnel* was the direct consequence of the principle upon which, in every country of Europe except Austria, the field batteries were formed. This principle was, that field and garrison batteries are interchangeable—a principle which, from whatever point of view it is regarded, is absolutely and radically false.

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1 For a detailed account of the effects of *corps d'élite* in the French service, see Kinglake's "Hist. of the Crimean War," Vol. II. p. 390 *et seq.*, and Trochu's "L'Armée Française en 1867," p. 201 *et seq.* The ruinous consequences of this system in the garrison batteries of the Bengal Artillery, are admirably described by Sir Henry Lawrence, in his "Essays, Political and Military," p. 19 *et seq.* Some general remarks on the subject may be found in the "Considérations sur L'Infanterie," by H.M. Charles XV., the late King of Sweden; and in "Studies of the Recent War," in the "Edinburgh Review" for April, 1871, p. 557 *et seq.*

2 "At present" (1818) "the cut of the clothes and general equipment" (of the gunner and driver) "are altogether those of the infantry soldier; and when mounted, his coatee, chaco, and infantry great coat convey the idea of a foot soldier mounted on some emergency, and not of one engaged in the performance of his proper and appropriate duties."—"Aide-Mémoire to the Military Sciences," Art. "Gunner."

3 "In whatever way the men may be carried, in order that, after a rapid movement, they may, on getting into action, begin unfatigued the laborious duty of working the guns, it is clear that the effect of the fire is the same. Once unlimbered, it is the same how, or by what means, the guns were brought, or the men carried to the assigned point; nor can there be any difference whether the men who work the guns belong to one branch of the artillery or to another. The only real difference will arise from skill, bravery, and previous instruction."—"Remarks on the Organisation, &c., of the Royal Artillery," by Sir Augustus Frazer, K.C.B., R.H.A. London, 1818, p. 34.

"The men" (of the horse artillery) "though mounted for the mere sake of expeditious movement, are neither more nor less than other artillerymen the moment the guns are brought into action."—Ibid. p. 37.

4 "The difference of the uniform of the horse artillery drivers and those of the rest of the service, may appear but a trifling consideration; but the drivers want encouragement, and everything should be attended to which tends to do away with useless distinctions."—Ibid. p. 82.

The ordnance service is naturally and necessarily divided into two grand primary divisions—the artillery that follows an army into the field, and the artillery that does not; the artillery whose success depends not only on its fire but on its mobility, and the artillery whose success depends wholly and entirely on its fire; the artillery of motion, and the artillery of rest; field artillery and garrison artillery. Such a division is no matter of opinion or choice; it is a division made necessary by the nature of things. This division forms the first principle of artillery organisation, and any organisation which neglects or contravenes it must be faulty and vicious.[1] This principle, self-evident as it now appears, was almost universally disregarded or overlooked at the beginning of the century; and it was generally agreed that the artillery service should be divided, not into field and garrison artillery, but into horse artillery and the rest of the artillery. As well divide the revolutions of the sun into evening and the rest of the twenty-four hours! As well divide the habitable globe into valleys and the rest of the earth's surface! As well divide the human race into gunners and the rest of mankind![2] In Austria alone the primary principle of all artillery organisation was never lost sight of, and was always acted upon. There only the field batteries were always recognised as an integral and necessary part of the field artillery; elsewhere they were looked on and treated as an offshoot of the garrison artillery. They were called field batteries by courtesy, but they were in truth an incoherent mass of garrison gunners, field guns, and, in many cases, farm horses and ploughboys.

Little wonder that while such clouds lowered over the field batteries, they were hidden, not in the shades of "disastrous twilight,"[3] but in the "gloom of infernal darkness!"[4]

In 1793, the gun carriages and ammunition carriages of the English army in Flanders were "of very faulty construction, and the drivers were either hired men, or men borrowed from the infantry. . . . . . The carriages were of single draft, and the drivers were in consequence on foot, having generally three horses to each driver. . . . . . At this time, however, the British artillery had the mortification of seeing the English wagons which were furnished to the Hanoverian artillery drawn by four horses, and driven by two drivers mounted. During the campaign of 1793,

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1 "Feld- und Festungs-Artillerie als zwei getrennte Truppenkörper, jeder mit seinem eignen, seinem Wesen entsprechenden Officiercorps und mit eigener selbstständiger Organisation, formirt werden sollen."—"Wie soll die Trennung der Feld- und Festungs-Artillerie bewirkt werden." Leipsig, 1872, p. 21.

"Feld- und Festungs-Artillerie . . . wenig mehr gemein haben, als die Theorie der Flugbahnen ihrer Geschosse."—"Die Schäden der Organisation der Preussichen Artillerie." Leipsig, 1871, p. 6. See also "Die Erfolge der Preussischen Feld-Artillerie in der Campagne 1870-71." Leipsig, 1872, p. 10.

2 The three rules of a good logical division are:—1. Each of the parts, or any, short of all, must contain less (*i.e.*, have a narrower signification) than the thing divided. 2. All the parts taken together must be exactly equal to the thing divided. 3. The parts, or members, must be opposed—*i.e.*, must not be contained in one another. See Reid's "Account of Aristotle's Logic," Chap. 2, Sect. 2. A moment's consideration will show that the division of the artillery service into horse artillery and the rest of the artillery, is a flagrant violation of the third rule.

3 "Paradise Lost."

4 I borrow this phrase from Eusebius, the ecclesiastical historian, quoted in Gibbon's "Decline and Fall of the Roman Empire," Vol. III. p. 9. Murray's Ed.

many necessary improvements were suggested and reported to the department at home; but their adoption having been refused, the artillery took the field in 1794, little otherwise benefitted by the preceding campaign than by the knowledge of its own defects. . . . . . Although the remedies to these defects were simple and obvious, yet we find, even in the home encampment near Swinley, in the year 1800, the system was not abandoned. . . . . . By this time, the superior efficiency of the horse artillery, from having its officers, men, and horses regularly appointed, and constantly fixed to the same guns, became apparent; and the reflective part of the corps could not but hope that a system so obvious to reason and so demonstrably proved by practice, would be generally adopted in the field artillery. . . . . . Yet nothing was done, and no brigades or organised bodies of field artillery were formed."[1] The contract drivers and horses attached to the guns were partly English, partly Dutch.[2] Add that the battalion gun system was in full force, and the picture is complete. As might be expected, numbers of guns were lost during these unfortunate campaigns,[3] in spite of prodigies of valour performed by the artillery officers and gunners. But such mishaps were then thought lightly of, and the loss of a quantity of ordnance at the battle of Mouveaux, 1794, was communicated to the army in the following words:—

"HEAD-QUARTERS,
Tournay, 19th May, 1794.

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"In fact, the enemy has little to boast of, but the acquisition of some pieces of British artillery."[4]

Some pieces of British artillery! This order has only been surpassed by that of another commander who, nineteen years afterwards, lost his guns at Tarragona. "They were of small value: old iron! He attached little importance to the sacrifice of artillery; it was his principle." "Strange indeed!" says Napier. "Great commanders have risked their own lives, and sacrificed their bravest men, charging desperately in person to retrieve even a single piece of cannon. . . . . . Sir John Murray's argument would have been more pungent, more complete, if he had lost his colours, and pleaded that they were only wooden staves bearing old pieces of silk."[5]

In 1798, as Qr.-Mr. Tate relates, the Commandant of Woolwich inspected some guns manned by gunners of the 8th Battalion, R.A. The guns were each drawn by three horses in single file, which were driven by contract

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[1] "Remarks, &c.," by Sir Augustus Frazer, K.C.B., R.H.A. p. 50, *et seq.*

[2] I have unfortunately lost my notes on this point, and am obliged to quote from memory an article in an old number of "Colburn's United Service Magazine," entitled (I think) "Woolwich, Fifty Years Ago."

[3] I was at some pains, in 1866, to calculate the number of guns we lost during these campaigns, from MS. documents in the French War Office, to which I gained access through the kindness of Col. Cleremont, the English Military Attaché, and Marshal Niel, the French Minister of War. My labour was in vain, however, as the French generals only reported the *total number* of guns taken in each action from the allies, without specifying the number belonging to the Dutch, Hanoverians, Germans, and English respectively.

[4] General orders by H.R.H. the Duke of York, quoted in the "British Military Library," Vol. II.

[5] Napier's "Peninsular War," Vol. V. p. 159.

drivers on foot, hired for the occasion, dressed in white smocks with blue collars and cuffs, and armed with long carters' whips of the ordinary farm pattern. When this formidable array had been reviewed, the Commandant, General Lloyd, and the Garrison Adjutant, expressed their joint opinion that field artillery movements could not be performed quicker![1]

Matters had not mended in the year 1800; and Sir Robert Gardiner's description of the field batteries of that time is by no means overcoloured. "Picture to yourself," he says, "a few guns advancing against a strongly-posted enemy, drawn by horses in single file, driven by a civilian on foot, wielding a carter's whip, the carriage of the gun receiving its direction from a trail-truck, traversed by a handspike. We were an absolute encumbrance to the army, and often a source of embarrassment to its movements."[2]

The Egyptian expedition, under Sir Ralph Abercrombie, sailed from Malta on the 21st Dec. 1800, without horses, and put in to Marmorice Bay, in Asia Minor, on the 1st Jan. 1801, to take on board horses for the artillery and cavalry, and the Turkish Contingent that was to accompany it. When the horses, which had been bought at Constantinople, arrived, the dragoons were given the first choice, those rejected by the cavalry being "turned over to the artillery."[3] The horses chosen by the cavalry "were naturally bad, and in such a shocking state as to make the dragoons feel humiliated in being ordered to take charge of them."[4] When such was the state of the best horses, selected by the cavalry, the condition of those "turned over" to the artillery may be more easily imagined than described. "Such poor, undersized animals as they were, rendered it absolutely necessary not only to take the harness entirely to pieces in order to bring it anything near fitting them, but also to lay aside all the heavy parts—such as neck-collars, chain-traces, kurb-bits, &c.—and to replace them with light leather breast-collars, rope traces, and pads formed out of the wagon harness."[5] The cavalry took 200 of these beasts, the artillery about 130, and "the remainder were shot, or sold for a dollar apiece."[6] The fitting of the harness was only one of the many serious difficulties which the artillery officers had to surmount; for not only were the horses low-bred, in bad condition, and deficient in numbers, but they were unbroken, unteamed, untrained to artillery manœuvres, and unaccustomed to the sound of guns. "Drivers were also very much wanted, several of those which came out originally with the battering train having, with their officer, returned in a very unaccountable manner to England;"[7] the garrison gunners had to be instructed in field artillery drill; and guns had to be organised on the off-horse system to support the cavalry, which was much inferior to the French. Under ordinary circumstances there would not have been time to carry out changes

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[1] "Aide-Memoire to the Military Sciences." Art. "Ordnance."

[2] "Observations, &c., on the Royal Artillery." 1856. p. 9.

[3] "The Expedition to Egypt." MS., by General Lawson, R.A., in the Royal Artillery Library, Woolwich, p. 1.

[4] Sir Robert Wilson's "Expedition to Egypt." 1803. p. 7.

[5] General Lawson's MS.

[6] Sir Robert Wilson's "Expedition to Egypt."

[7] General Lawson's MS. The expedition, before sailing for Egypt, had made an unsuccessful attack on Cadiz, and from there had made for Lisbon, where the drivers and their officer disappeared.

which virtually amounted to creating a field artillery; but luckily for the *prestige* of England, the Turks refused to embark during the solemn fast of Rhamadan, and the expedition was in consequence delayed in Marmorice Bay till the 20th February. Thus, owing to a happy accident, breathing time was given to the artillery officers to carry out their heavy task.

Having landed and parked his guns, General Lawson's first step was to equip four 3-prs. on the off-horse system, to accompany the cavalry. The shafts of the 3-pr. carriages, which were permanent, and only intended for single draught, were cut off at the splinter-bar; poles were introduced; and teams of four, or when they could be spared six, horses were told off to the guns. Only one N.C. officer and three men were available for each gun; two gunners riding on the off horses of the team, the N.C. officer and the other gunner on the limber. The reserve ammunition for these guns was carried in hand-carts, which were adapted for draught on the curricle principle, and drawn by four horses. Four light 6-prs., on block-trail carriages, and two royal howitzers, were also equipped on the off-horse system. "It was very much wished to have exchanged the limber shafts for poles, on account of their weight, as well as other considerations; but no wood could then be procured, even in the island of Rhodes, for the purpose."[1] Ten horses, two abreast, were told off to each 6 pr. A driver was mounted on the near leader, a gunner on each of the lead centres, a driver on the near and a gunner on the off centre, a gunner on each of the wheel centres, and a driver on the near wheeler. A N.C. officer and a gunner sat on the limber boxes, which contained 60 rounds of ammunition. Thus each gun was manned by one N.C. officer and six gunners. The 6-prs. on bracket carriages required twelve horses when going over heavy sand or shingle. These horsed guns were commanded by Major Macdonald. The 12-prs., under Lieut. Adye, were drawn to Cairo by oxen, with a horse in the shafts.[2]

From whatever point of view it be looked at, the conduct of the home authorities in dispatching upon active service a force of artillery in a state of absolute and complete disorganisation, was disgraceful and unpardonable. Had the English artillery been found wanting in the hour of need, no blame would have been too heavy to heap upon the devoted heads of Lawson, Macdonald, and Adye. By their unflagging zeal and unusual ability they covered themselves with glory; holding their own with 6-prs. and royals, ill-trained gunners, untrained drivers, improvised harness, and wretched horses, against the French horse artillery, composed of 8-prs. and 6-in. howitzers, and drawn by the finest horses in the army.[3] Yet I am not aware that any distinction was conferred on them for their admirable services! No officers ever proved themselves worthier of the honor of holding commissions in the Royal Artillery.

It is improbable that so able an officer as Lawson failed, on his return home, to represent the difficulties in which the artillery had been involved in Egypt, from the disorganisation of the *personnel* and the deficiency of the means of draught. Nothing, however, was done; for men had not yet grasped the truth that the field artillery service cannot tolerate mediocrity,

[1] General Lawson's MS.
[2] Ibid.
[3] Ibid. p. 29.

and that it must be either perfectly efficient or wholly useless. "An ill-appointed, uninstructed artillery is more an encumbrance than an advantage to an army."[1] "Something may be made of bad cavalry, or indifferent infantry, but bad artillery is good for nothing. Artillery, unless a powerful arm of assistance, is a clog and embarrassment to the movements of an army."[2] Not only was nothing done then, but for many years after the field batteries remained in a condition which is best described in the words of Sir Augustus Frazer :—

"At Woolwich, the head-quarters of the corps, and the source, or supposed source, of instruction, officers were occasionally directed by the orders of the garrison to take out field guns to exercise; receiving (garrison) artillerymen from the adjutant on duty, the drivers from the driver corps, and the guns from a park formed for the purpose. If, in seasons of more than usual diligence, this field exercise was repeated in the course of the same day, the artillerymen, drivers, and horses were generally different in the afternoon from those in the morning. It is needless to say that this strange mode of attempting to teach what is only attainable by patient, quiet, and repeated instruction under the same person, could lead to nothing but confusion. . . . . . On its being intended to send out an expedition from England, the companies of (garrison) artillery which are intended to accompany it receive orders to hold themselves in readiness for foreign service. These companies are generally—indeed it might be said always—at different stations, usually belong to different battalions of artillery, and, as may be supposed, are frequently in very different states of readiness and efficiency. A commissary of ordnance is also put under orders, and is charged with the responsibility of the ordnance, ammunition, and stores. . . . . . The drivers and horses required for the service are assembled from various points, and are embarked under the direction of the senior officer of the driver corps. The drivers and horses are not told off, or distributed to any number of guns or carriages, but are embarked in one disposable body. In this situation it becomes the duty of the senior artillery officer, after he shall have received the directions of the general commanding the expedition, to arrange the arm committed to his charge; to fix the number of brigades[3] of artillery, and of how many field pieces, and of what calibre of those embarked they shall consist; to determine what companies shall be applied to the brigades, and what shall remain in reserve; how the field officers shall be distributed; how the drivers and horses shall be told off; how the reserves of ammunition, both for artillery and small-arms, shall be appointed; and, generally, how an organised body shall be formed out of the component parts which successively arrive from different stations at the point of debarkation. Let it be supposed that these component parts are all, separately, good; that the officers and men are well-equipped and well-instructed; the drivers in all respects well-appointed and drilled; and the horses strong and well-trained. Yet, even on this supposition, these parts must be unknown to each other; there must

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[1] "Illustrations of the Numerical Deficiency, &c., of the Royal Artillery," by Sir Robert Gardiner, K.C.B., R.H.A. 1849. p. 11.

[2] "Remarks, &c., on the Royal Artillery," by Sir Augustus Frazer, K.C.B., R.H.A., p. 45.

[3] *i.e.* batteries.

be a want of unity of system; the officers must receive their ordnance and ammunition on the faith of the commissary, and almost without examination; the harness cannot be expected to fit; new regulations as to interior arrangements must be made at the moment, and under all the disadvantages of hurry and of every individual's being placed in a new situation. In short, under the most favourable circumstances . . . . . all that can be effected is . . . . . . that the brigades are put together and hastily formed.

"But if, instead of this, it be supposed—as is known to be the real case—that in companies coming from different points, and from different services, very different degrees of instruction or efficiency exist; if some have not for years gone through even the bare formality of a drill with field guns . . . . . if the drivers be in many cases ill-instructed, and in others not at all; if their accounts be entangled in confusion; if the horses be frequently of an indifferent description, and rarely, as a body, in that state of good condition which a mass unbroken into regular subdivisions seldom attains; if harness tried for the first time cannot, without many little unavoidable alterations, fit horses of different shapes; if, in short, all the various parts of which the field artillery is composed be in this unformed state; what can for some time be expected from it, even if it should not be immediately brought in contact with the enemy?"[1]

This state of things did not escape the notice of foreign officers. "In spite of the want of a judicious and systematic organisation," says the Prussian Scharnhorst, writing in 1806, "the English Artillery has always been distinguished for its bravery. Their conduct at Minden gained for them the special thanks of Prince Ferdinand, and the successful defence of Gibraltar was entirely due to them. In the wars of the French Revolution no soldiers were before them in willingness and courage; but their frequent want of ammunition, the bad condition of their horses, &c., &c., show that their organisation is a faulty one."[2] Scharnhorst had need to pray, with the poet:—

"O wad some Pow'r the giftie gie us,
To see oursels as ithers see us!"

The same large general causes which in England had humbled the field batteries in the dust, were in full action in Prussia—intensified, strange to say, by the personal influence of Scharnhorst himself; and if the English field batteries were bad, the Prussian field batteries were not one whit better.

Towards the end of the last century the Prussian artillery produced two officers of great note—Templehoff and Scharnhorst.[3] Both were men of eminent culture and ability, both were good writers, both were good soldiers, both were men of energetic character, and both reached high positions in the service; yet the mind of either was warped by prejudices—differing though they did from those of the other as noon from midnight—which lessened his influence and marred his usefulness. Templehoff loved the field batteries, and hated the horse artillery; Scharnhorst loved the horse

[1] "Observations, &c." by Sir Augustus Frazer, K.C.B., R.H.A.

[2] "Handbuch der Artillerie," Band. II. p. 607.

[3] For a general account of the lives of these great men, see the "Biographie Universelle," and the "Conversations-Lexikon." Adorf, 1841.

artillery, and hated the field batteries.[1] Templehoff, justly considering the field batteries to be the most important, because the most formidable, branch of the field artillery service, unfortunately could discover no other way of raising them than by depressing the horse artillery; and with deplorable consistency, he spent his life in improving the field batteries by humiliating and persecuting the horse artillery. Scharnhorst, on the other hand, regarding the field batteries as a respectable branch of the garrison artillery, exhausted all his resources in exalting the horse artillery by trampling the field batteries under foot. It is melancholy to look back on the unprofitable and unreasonable contentions of these really able men. Had they gone hand-in-hand—as the leaders of the horse artillery and the field batteries should ever go; had they been able to lift up their eyes and look upon the field artillery as a whole, instead of concentrating all their attention upon one branch of it; had they understood that the interests of the horse artillery and field batteries are identical, instead of being antagonistic; then their efforts would have been crowned with success, and they would have left the Prussian field artillery the first in Europe. As it was, their labour was to a great extent unproductive; for the exertions of the one were almost entirely neutralised by the counter-exertions of the other, like

> ". . two spent swimmers that do cling together,
> And choke their art . . . ."[2]

Scharnhorst, however, survived Templehoff.[3] His power was thus for some time unchecked, and his influence consequently intensified, in some degree, the effect of the general causes which conspired to depress the field batteries all over Europe. The result was that the Prussian field batteries were well nigh unfit for service.

After the peace of Basle, 1795, all progress and improvement ceased in the Prussian artillery, and it entered upon a glacial period of inactivity and torpor resembling that through which the French artillery passed before Gribeauval appeared. In 1799 this period of stagnation was interrupted by a re-organisation founded on the principle—false to the core—that one company should man two batteries. Every practical consideration seems to have been forcibly thrust out of sight in framing the new scheme, which rendered it almost impossible to carry on the duties of the arm in the field. Field officers[4] commanded batteries they had never seen before, and the fifth officer of a company[5] was made Adjutant, whether he was fit or not. The bitter experiences of 1806 and 1807, however, when all the failings and shortcomings that had been nourished and cherished during a long peace were brought to light, taught the Prussian artillery officers lessons never to be forgotten. During these unfortunate wars, it required the unsleeping vigilance of the officers to prevent the batteries from breaking down altogether. In the executive knowledge of their own profession, in a knowledge

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[1] "Die Beziehungen Friedrich des Grossen zu seiner Artillerie." Von Troschke, pp. 17-18. "Ueber Reitende Artillerie, &c.," passim. "Geschichte des Geschützwesens, &c." C. von Decker, p. 155.

[2] Macbeth.

[3] Templehoff died in 1807; Scharnhorst was killed in 1813.

[4] "Staabsofficiere."

[5] "Staabs-Kompagnie."

of cotemporary tactics, in everything required for the practical application of their arm in the field, the men, N.C. officers, and young officers were mere civilians. The horses and drivers, both quite untrained, joined the artillery only a few days before a march. The unfortunate drivers were wretchedly clothed, and commanded by some broken-down old cavalryman, under the title of *Schirrmeister*. Little attention was paid to the harness, and it was usually in the collar-maker's hands after a few marches. The wheelers and shoeing-smiths were unskilled; no two wheels were matches; one gun would not fit the carriage of another, and frequently did not fit its own. The spare stores,[1] packed in an absurd way, were carried on a spare gun carriage; but they were of little use, as they bore little resemblance, in shape or dimensions, to those they were intended to replace. Furthermore, while there was an abundance of perfectly useless articles, the most necessary stores were wanting. The carriages were overladen with superfluous iron fittings, among which the drag-apparatus was conspicuous for badness. Thus clumsily equipped, meanly horsed, manned by unpractised gunners, and deficient in numbers, the batteries took the field, and found themselves brigaded with other troops as unaccustomed to the artillery as the artillery was to them. Utter strangers to each other to-day, to-morrow they would be fighting shoulder to shoulder for victory! Only two officers were attached to batteries of eight or ten guns; the fractions of which, when detached, were frequently entrusted to young officers or under-officers. Hence arose innumerable collisions with the other troops, in which the artillery invariably went to the wall. The safety of the guns in action was often compromised, because artillery tactics were not understood, and the defence of the guns was not made an affair of honour, as it is now. It would be hard, however, to blame the infantry and cavalry officers for their ignorance of field artillery tactics, when the artillery officers themselves were not agreed on the subject. In action, the batteries crawled from one lofty height to another—a venerable mode of manœuvre, consecrated by the dust of ages, which one generation of artillerymen copied from another without asking the reason why. Looked upon in quarters, on the march, and in action, as a hindrance; considered by the wise as a necessary evil; reluctantly called into the field; and neglected and despised when peace returned; such was the condition of the Prussian field artillery in 1806 and 1807. Then it was that the malign influence of Scharnhorst was felt. He was now supreme, for Templehoff was dead. The field battery officers were only too willing to profit by the lessons of adversity; but there stood Scharnhorst, resolute to stop every improvement, determined to bar all progress. Eager to raise the horse artillery, he depressed the field batteries; and the foregoing description, originally intended to illustrate the condition of the Prussian medium field artillery before the peace of Tilsit,[2] was applicable to it for many years afterwards.

The minute description I have given of the English and Prussian field batteries renders it unnecessary to dwell upon the French, which were under precisely the same circumstances. Suffice it to say that although they were bad in everything that related to their means of draught,[3] and although their

[1] "Vorrathssachen."

[2] C. von Decker. "Geschichte des Geschützwesens und der Artillerie." Berlin, 1822, p. 13, *et seq.*

[3] Général Lespinasse. "Essai sur l'organisation de l'arme de l'Artillerie." 1800. pp. 57, 58.

want of mobility was consequently great, they were on the whole perhaps a shade better than the English and Prussian.

I have searched so long and so vainly for books bearing on the state of the Austrian field artillery at the time I speak of, that I believe no such books exist. Judging, however, from the slender materials at my disposal, I am inclined to think that the Austrian field batteries were the best in Europe. "Dass, die Osterreichische Artillerie. . . . . . leichter ist, und weniger als eine jede andere kostet, verstiehet sich von selbst," says Scharnhorst,[1] who looked on the Austrians with by no means favourable eyes. But owing to the misapplication of true principles, the Austrian field artillery was far from being perfect. On the one hand, their light field artillery never did, and never could, rival the English, French, or Prussian horse artillery in *élan* or efficiency; because the Austrians adopted a clumsy form of the gun-carriage system, which I consider to be inferior to the detachment system for this service. On the other hand, the Austrians marred the efficiency of their field batteries by failing to develop to the utmost the gun-carriage system, on which they had wisely organised them. Still, owing to the absolute rejection by the Austrians of the preposterous principle of the interchangeability of field and garrison artillery, their medium field artillery escaped the dangers of that Slough of Despond in which the English, French, and Prussian were wallowing.

Having described at length the forces which depressed the medium field artillery at the beginning of the century, it is now necessary to consider the counter-forces whose action saved the field batteries from extinction.

I.—The first of these was the costliness of horse artillery. Had it been possible to equip batteries of light artillery on the detachment system at the same cost as field batteries, it is more than probable that an enormous increase in light, and a corresponding decrease in medium field artillery, would have taken place at once. The great expense of horse artillery, however, was a powerful bar to its extension beyond certain limits, and necessitated the retention of the cheaper batteries.

This cause was of special importance at the period of which I am speaking, because every state in Europe was more or less impoverished by the incessant warfare of the French Revolution and Empire.

The estimates that have been formed of the cost to England alone of the wars of the French Revolution and Empire, 1793–1815, vary from £601,000,000,[2] to £780,000,000.[3] The Crimean war cost the powers engaged in it £340,000,000; the Italian campaign of 1859 cost £60,000,000; the American civil war cost the Federals £940,000,000, and the Confederates £460,000,000; the war of 1866, which lasted only a few weeks, cost Prussia, Austria, and Italy £66,000,000.[4] Such were the sums of money spent on the wars of the present century, and spent unproductively; for, from the nature of the case, war expenditure must be unproductive.

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[1] "Handbuch der Artillerie." Hanover, 1806. Band II. p. 546.

[2] "Statesman's Year Book." 1870.

[3] Knight's "Political Dictionary." Art. "National Debt."

[4] "Cotemporary Wars," by M. Beaulieu. Translated from the French under the direction of the London Peace Society, 1869, p. 56. The Peace Society are not likely to under-estimate the cost of war, but their figures no doubt approximate to the truth.

Vast sums may be spent, vast debts may be incurred, in the construction of railways, harbours, telegraphs, &c., &c., but this expenditure may be, and generally is, productive; for the objects on which the money is spent are "sources of annual revenue and advantage."[1] War expenditure, however, is necessarily unproductive. There is nothing to show for it; and the money thus spent is as irretrievably lost as if it were cast into the depths of the unfathomable ocean.

But the cost in money by no means represents the total loss of wealth sustained by a nation involved in war. "What encourages the progress of population and improvement, encourages that of real wealth and greatness."[2] War, consequently, diminishes the wealth and decreases the absolute, though not necessarily the relative greatness of a nation; because it retards improvement, and is a deadly enemy to the progress of population. The following figures will give some notion of the frightful loss of life occasioned by the wars of the present century:—M. de Pradt estimates the French loss in the six Peninsular campaigns, 1808–14, at 600,000 men. During the Crimean campaign 785,000 men were killed in battle, or died of wounds or disease. In the Italian war, 1859, 45,000 lives were sacrificed. The Federal armies lost 281,000 men during the civil war, 1861–66; the Confederate armies 519,000. The total loss in the war of 1866 was 45,000.[3]

It is not too much, then, to say that every state in Europe was more or less impoverished by the wars of the French Revolution and Empire; it is not too much too infer that the lavish expenditure of men and money occasioned by these desperate and prolonged campaigns proved a formidable barrier to the extension of horse artillery beyond certain limits.

II.—The second cause that acted favourably for the field batteries, was the diminished efficacy of fire at which the increased rapidity of manœuvre of the horse artillery was necessarily purchased. Hurried into existence at a moment when the whole atmosphere of Europe was heavy with war, it is not surprising that at first but little enquiry was made about the capabilities of the flying artillery; and its brilliant and successful action was quite sufficient to stifle any little enquiry that might have been set on foot. French commanders were calling for horse artillery, and nothing but horse artillery; its influence in Prussia was paramount; and an English political officer in 1809 reported to his Government that a force of flying artillery and cavalry would suffice to drive the French from Spain![4] But a few years' experience in the field opened men's eyes to the fact that the rapidity of manœuvre of field artillery ultimately depends upon the simple mechanical principle of Work.

Let W be the total weight behind a team of horse artillery horses, and W' the total weight behind a team of field battery horses. Let the teams, which consist of an equal number of horses in either case, be applied, for equal times, to draw the guns at constant velocities. Now, since the teams, and consequently their powers of traction, are equal, and they are applied

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[1] Prof. Thorold Roger's "Political Economy," p. 298.
[2] Adam Smith's "Wealth of Nations." Roger's Ed. Vol. II. p. 146.
[3] "Cotemporary Wars," p. 55.
[4] Napier's "Peninsular War." Vol. II.

for equal times, the work done in either case is equal.[1] In other words, if S be the space through which the horse artillery gun is drawn in a certain time, and S' be the space through which the field battery gun is drawn in the same time,

$$WS = W'S'.$$

Now, for constant velocities,

$$S = VT \text{ and } S' = V'T',$$

therefore

$$WVT = W'V'T'.$$

But by hypothesis,

$$T = T',$$

therefore

$$WV = W'V'.$$

Or, the velocities at which the teams move are inversely proportional to the weights behind them. In other words, what is gained in rapidity of manœuvre is lost in efficacy of fire. I shall not pause to expose the stupidity and ignorance of those who have called the field batteries "bastard horse artillery," and accused them of "aping horse artillery." The field batteries, as is clear from the foregoing considerations, can no more ape the rapidity of manœuvre of the horse artillery than the horse artillery can ape the efficacy of fire of the field batteries.[2] The longer the wars of the French Revolution raged, the more forcibly was the truth of this principle proved by experience in the field, and the more clearly did men see that the strength of the field batteries could not be safely reduced below a certain limit.

Such were the causes which determined the relative positions of the horse artillery and field batteries at the beginning of the present century. It remains to describe the influences which conferred a considerable impetus on the progress of improvement in the field artillery service at large at that period.

NEWPORT, MONMOUTHSHIRE,
November, 1872.

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[1] This mode of treating the question is not strictly correct, the horse being a live agent, not a machine. It is, however, sufficiently correct for practical purposes.

[2] Sir Robert Gardiner puts this principle very clearly in his "Report on the Numerical Deficiency, &c., of the Royal Artillery." 1848. p. 25.—"The necessary quick movements of the horse artillery cannot be attained by 9-prs.; the telling effect of 9-prs. cannot be expected from horse artillery."

THE SPONTANEOUS

IGNITION OF OILED COTTON OR SILK-WASTE.

CONTRIBUTED BY

MAJOR V. D. MAJENDIE, R.A.

THE following paper on the spontaneous ignition of oiled cotton-waste, and similar materials, will possess, it is believed, a practical value —at any rate, for those officers of the regiment who are engaged in the management of the Government factories, or who have charge of stores and other establishments in which, on the one hand, the improper and dangerous collection of greasy waste is a risk which can only be effectively guarded against by constant vigilance, while, on the other hand, the consequences which might result from the accumulation of a material so prone to spontaneous ignition would be most disastrous. It is doubtful if this risk is always recognised to its full extent by those who are interested in its exclusion. Certainly, in many private gunpowder and firework factories the necessity of strictly forbidding oiled cotton-waste in the powder buildings is not adequately appreciated; and it is no uncommon thing to find this material deposited in corners of the press and corning houses, on the window sills, or even in some instances among the semi-manufactured powder.

The accompanying paper shews that oiled cotton waste is an article which requires only a very moderate heat and no great mass of the cotton to produce ignition. In one instance, it will be observed, "a quantity of oiled cotton that just filled a common lucifer match box" ignited after an hour's exposure to 165° Fahr. In other instances about one-sixteenth of a cubic foot of the material ignited at a temperature of 130° Fahr. These facts illustrate the grave and urgent character of the risk which exists when oiled cotton waste is deposited, even in very small quantities and for a very short space of time, in moderately elevated temperatures—such temperatures as exist in the majority of factories, in the neighbourhood of a steam-pipe, or under exposure to the sun's rays.

Since the foregoing remarks were written, Mr. Galletly has, at my suggestion, made some experiments with silk-waste in comparison with cotton, in order to determine how far the danger which undoubtedly exists when the latter material is present, would be got rid of by the use

of silk. The investigation has not yet proceeded far enough to warrant any detailed account of the experiments being given—that must be reserved for a future occasion; but it may be worth while to state that, so far as the inquiry has gone, it seems to show that the risk in *gunpowder* buildings is in no degree diminished, but rather the contrary, by the use of silk-waste. Mr. Galletly writes:—"A little powder in the centre of silk waste ignited in an hour, while a little amongst the cotton did not ignite for an hour and a half. On the other hand, the cotton reached actual incandescence in about the hour and a half, whilst the silk was merely charred, and indeed never got red hot at all."

In a subsequent letter, Mr. Galletly says:—"I have put up silk and cotton-waste to-day at 2 p.m., with boiled linseed oil—chamber at 120° Fahr. Silk exploded gunpowder at 4.10 p.m., and cotton not yet, (5.20 p.m.)"

Mr. Bloxam observes, with regard to these results:—

"Rumford found, for the times of equal cooling, in

Sewing silk	917
Lint	1032
Cotton	1046
Wool	1118
Raw silk	1284

"The conducting powers would of course vary inversely as these numbers. It might therefore be expected that the inside of the mass of silk-waste would become hotter in a given time than the cotton-waste, which would conduct the heat more rapidly outwards. As to the charring, cotton is of course, in itself, a more inflammable material than silk, so that I should expect it to take fire at a temperature which would only suffice to carbonise the silk. . . . . . The powder would of course fire as soon as a definite temperature was reached, whether the material around it actually inflamed or not."

Mr. Bloxam also suggests that possibly as "the oil would soak more thoroughly into the cotton than into the silk, the latter being merely varnished over with oil, would expose more on the surface to the oxidising action of the air, and would therefore *heat* more readily, though it would not inflame, on account of the want of inflammability of the silk itself."

The conclusions are clear:—

(1) That oiled waste, whether of silk or cotton, should invariably be regarded with suspicion, as liable to spontaneous ignition under moderately elevated temperatures.

(2) That silk waste is at least as dangerous as cotton, or even more so, in a building containing gunpowder, or other material which is capable of being ignited or exploded without the actual application of flame.

V. D. M.

HOME OFFICE, WHITEHALL, S.W.,
January 1873.

IGNITION OF COTTON BY SATURATION WITH FATTY OILS.

By John Galletly.

Read at Brighton Meeting of the British Association, August, 1872.

The following experiments have been made with the view of giving greater precision to our knowledge of the kindling of cotton or other open combustible materials which happen to have imbibed animal or vegetable fatty oils. Graham* mentions "that instances could be given of olive oil igniting upon sawdust; of greasy rags from butter, heaped together, taking fire within a period of twenty-four hours." The danger of fire from this cause is familiar to those manufacturers who coat any textile fabrics with varnishes containing drying oils, and also to turkey red dyers, from the olive oil employed in their process. Generally, it is stated in "Watts' Dictionary"† that this combustion "may take place in intervals varying from a few hours to several weeks, when considerable masses of lamp black, tow, linen, paper, cotton, calico, woollen stuffs, ships' cables, wood ashes, ochre, &c, are slightly soaked in oil and packed in such a manner that the air has moderate access to them." Nevertheless there is great vagueness about the exact conditions in which actual ignition of the mass would take place, what size of a heap might be necessary, and the various powers of different oils to produce this result. Graham states, in the report already quoted, that the ignition of heaps of the materials under discussion "has been often observed to be greatly favoured by a slight warmth, such as the heat of the sun." This is a very important observation. I shall only, however, mention in the meantime that the first of my experiments were made at a temperature of about 170° Fahr., but I have some made at a heat a little over 130°, or about the temperature a body acquires by lying perpendicular to the sun's rays; the former temperature might represent the heat attained in the neighbourhood of a steam-pipe, a heated flue, or in front of an open fire. For completeness I shall repeat in this paper, along with later results, some observations published a few weeks ago in the "Oil Journal."

Boiled Linseed Oil, with Chamber kept about 170° *Fahr.*—A handful of cotton-waste, after being soaked in boiled linseed oil, and removing the excess of this by wringing, was placed amongst dry waste in a box 17 ins. long by 7 ins. square in the ends. Through a hole in the cover of this box a thermometer was passed with its bulb resting amongst the oily cotton. Shortly after reaching the temperature of the warm chamber, the mercury began to rise rapidly—viz. from 5° to 10° every few minutes, and in 75 minutes from the time the box was placed in the chamber, the heat indicated was 350° Fahr. At this point, smoke issuing from the box revealed that the cotton was now in a state of active combustion, and, on removing it to the free access of air, it burst into flame. In another similar experiment the temperature rose more slowly, but reached 280° Fahr. in 105 minutes, when, from the appearance of smoke, it was plain that the cotton was burning, and the whole mass was soon in a flame on being placed in a current of air. On a smaller scale, I tried a quantity of the oiled cotton that just filled a common lucifer match box; within an hour it was on fire, the temperature of the chamber being 166° Fahr.

Raw Linseed Oil, as generally supposed, does not so readily set fire to cotton as the boiled oil, but in two experiments where the size of the box employed was 6½ ins. long by 4½ ins. square in the ends, active combustion was going on, in the one case in five, in the other in four hours.

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* Report on the burning of the steamer "Amazon." See Chemical Soc. Quart. Journal, Vol. V. p. 34.

† Vol. II. p. 880.

Rape Oil, put up as in first experiment on boiled linseed, resulted, in two trials, in the box and cotton being found in ashes within ten hours—the box being put up at night, the result was only observed in the morning. In another case I did not get the cotton to ignite in six hours; the chamber in the experiment with this oil and raw linseed was kept about 170° Fahr. With the five following oils 130° Fahr. was the temperature employed. The quantity of waste used was loosely packed in a paper box holding about the sixteenth part of a cubic foot.

Gallipoli Olive Oil.—The two trials made with this oil gave closely similar results; in one case rapid combustion was going on in a little more than five, and in the other within six hours.

Castor Oil.—I found the oxidation of this oil to proceed so slowly that only on the second day I found the interior of the box to be a mass of charred cotton. Its specific gravity (·963) is remarkably high, and its chemical nature very distinct from the other vegetable oils I have tried, which, no doubt, has some intimate connection with its small heating power.

I have tried three oils of animal origin with effects very distinct and instructive. *Lard Oil*, an oil of an ordinary specific gravity, viz. ·916, produces rapid combustion in 4 hours. *Sperm Oil*, which has a specific gravity of only ·882, and is not a glyceride, showed its unusual chemical character by refusing to char the waste. *Seal Oil*, which has a strong fish oil odour, not unlike the sperm, but a specific gravity of ·928, produced rapid ignition in 100 minutes.

Comparing raw linseed with lard and seal oils, it would appear that the statement is not altogether correct that "drying oils are more liable to spontaneous combustion than non-drying oils." I have also some reason to believe that the rate at which oxidation takes place does not chiefly depend on the presence of small quantities of azotized or other easily putrefiable matters, but rather on the particular olein, or liquid fat, they contain; however, further inquiry on this point is necessary.

I have made at least two experiments with each oil, and have got remarkably uniform results. The ignition of the cotton can be calculated on for any oil with about the same certainty as the point at which sulphur or other ordinary combustible material takes fire when heated in the air. So that the term "spontaneous combustion" may be objected to for the same reason that Gerhardt objects to "spontaneous decomposition" when produced by oxidation.

The heavy oils from coal and shale, being chiefly the higher olefines, have a remarkable effect in preventing this oxidation, undoubtedly, by giving a certain protection from the air. Mixtures of these oils with 20 per cent. rape gave no indication of heating whatever at 170° Fahr.; and even seal oil, with its own bulk of mineral oil added to it, did not, when placed in the chamber heated to 135°, reach a temperature sufficient to char the cotton.

NOTES ON CURVED FIRE.

SUBMITTED BY

COLONEL S. E. GORDON, C.B.

In a paper published in a late number of these "Proceedings," Captain Clarke, R.A., has called attention to the employment of curved fire by the Prussians at the siege of Strasburg, and shows that they successfully breached a hidden escarp at a range of 910 yds. with their 6-in. B.L.R. gun, with a charge of powder $\frac{1}{40}$th the weight of the projectile fired, which was 60 lbs.

In 1863, General Lefroy, F.R.S., published in Vol. III. of these "Proceedings," a paper "On Breaching Unseen Defences," which may be referred to with great advantage in reading the operations of the besiegers of Strasburg. He there proves that our 64-pr. B.L. gun, with a charge of powder $\frac{1}{40}$th, projects its shell with sufficient velocity to give a *vis viva* which will breach masonry at 900 yds.

From the result of a few rounds fired at the request of the writer at Shoeburyness, from a 64-pr. B.L. gun, with a charge of $\frac{1}{40}$th the shell's weight, a range of 900 yds. was obtained with an elevation of 15°; while in the Prussian account the range of 910 yds. is stated to have been obtained, with a proportionate charge, with only $7\frac{1}{8}°$ elevation.

It may be assumed that the 64-pr. B.L. gun has disappeared from our siege train, and therefore it is not practically material whether the Prussian 60-pr. has such a far flatter trajectory than our 64-pr. with these small charges or not. Still, if there is not a mistake in the elevation given, it would be a subject of interesting enquiry; because the flatter trajectory shows a greater initial velocity, and consequently more penetrative power.

The ranges obtained with charges of $\frac{1}{40}$th, $\frac{1}{35}$th, $\frac{1}{30}$th, and $\frac{1}{25}$th of the projectile's weight, from the guns which until a recent period formed our siege train, are given below. They are computed from the results of five rounds fired at each of the elevations of 10°, 12°, and 15°.

Gun.	Charge.	Proportion of charge to weight of shell.	Elevation.										
			5°	6°	7°	8°	9°	10°	11°	12°	13°	14°	15°
	lb. oz. dr.												
7-in. B.L.R. (72 cwt.)	3 9 9	$\frac{1}{25}$	560	670	780	885	985	1080	1175	1270	1350	1425	1500
	3 0 0	$\frac{1}{30}$	485	575	665	750	830	910	980	1050	1120	1185	1240
	2 9 2	$\frac{1}{35}$	420	500	580	660	74	800	860	920	975	1030	1085
	2 4 0	$\frac{1}{40}$	385	455	525	590	655	720	780	835	890	940	985
64-pr. B.L.R.	2 9 9	$\frac{1}{25}$	668	767	858	944	1027	1110	1190	126.	1307	1347	1376
	2 2 10	$\frac{1}{30}$	476	560	640	720	800	870	940	1010	1076	1135	1180
	1 13 11	$\frac{1}{35}$	470	550	615	680	740	790	834	875	917	953	990
	1 10 0	$\frac{1}{40}$	408	480	544	609	66	720	776	820	857	880	900
40-pr. B.L.R.	1 5 14	$\frac{1}{30}$	498	588	678	763	850	930	1006	1080	1150	122	1290
	1 2 12	$\frac{1}{35}$	444	526	610	690	766	835	900	967	1028	1090	1147
	1 0 6	$\frac{1}{40}$	360	430	500	565	634	700	765	830	890	950	1005

In obtaining these ranges, and in the practical use of the table afterwards in firing with very reduced charges at an earthen battery, it was curious to observe the effect of the heated gas of the exploded powder on the lead-coated projectiles. These having been exposed for a comparatively long time to its action, more of the surface lead was vaporised, and the smoke assumed consequently a deeper yellow tone than is customary when firing with the full charge. The bores of the guns became much more foul, and "shots" of lead were frequently found melted off in them.

"The Committee on High Angle and Vertical Fire from Rifled Howitzers and Mortars" have, in their last report, which has been published, recommended an 8-in. howitzer, with a twist of 1 in 16 calibres, and throwing a shell of 180 lbs., for permanent works of defence as well as for siege purposes; but the tables in the appendix of the report only furnish us with three cases in which the howitzer was fired so as to fulfil the conditions under which the breaches were made at Strasburg, viz.:—

Charge.		Yds.		°	′
4 lbs. or $\frac{1}{45}$th	gave	846	with	10	21
〃 〃	〃	1058	〃	13	19
10 lbs. or $\frac{1}{18}$th	〃	1147	〃	5	16

and in the latter the recoil appears to have been excessive, as "the breaching rope broke, 1st and 2nd rounds."

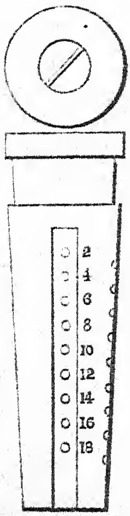
It is to be desired that tables be prepared with reduced charges for such guns as we shall use for our siege works in future, and that our artillerymen should be practised in making up the cartridges for, and working the guns with, these reduced charges; as we see in the extract from the report that "a want of training on the part of the gunners delayed the completion of the breach."

If high canvas targets, hidden behind earthen screens, could be used for practice with reduced charges, our artillerymen could be rendered much more efficient in this particular than they at present are. Unfortunately, we have only a Martello tower on the coast to destroy now and then, and consequently we are not likely to obtain much instruction in a more satisfactory way.

January, 1873.

102. Description of a Dummy Time Fuze.

(Communicated by Captain H. D. Evans, R.A.)



Service fuzes being too expensive to use at drill, and it being, however, essential to bore, fix, and uncap a fuze for every round, the following description of dummy fuze is suggested, having been used with great advantage by the writer :—

1. The fuze to be made of beech wood, and similar in shape to the service fuze, but a little longer and larger in diameter, in order that when fixed it should only go a short way into the shell. It could then be easily withdrawn from the shell, and if necessary the boring also could be examined by the instructor before it was handed to the No. 3.

2. The centre to be hollowed out from the bottom to within an inch of the top, and to be filled with sand or sawdust; the bottom to be covered over with paper only, so that the filling may be renewed; and on the top of fuze the false head of a screw should be cut.

3. A groove ·5 in. wide to be cut round the neck of fuze, and filled up with black Berlin wool, to represent the quickmatch of the service fuze; the top edge of groove to be ·25 in. from the top of the fuze.

4. ·25 in. from the lower edge of the quickmatch-groove must be cut grooves ·25 in. wide for the holes. They must reach down to the bottom of fuze, and be just deep enough to prevent the paper over them being torn when the fuze is fixed in the shell. In these grooves the holes must be bored; the top one of the even numbers ·25 in. from top of grooves, and the remainder ·25 in. apart. The holes must be made fully the size of the bit of service borer, so that when the latter is used at drill, the wood between the holes may not be damaged, and might be filled with putty, so as to offer some resistance to it.

5. The figures on the dummy fuze must be sunk a little, or perhaps only stamped deeper than on the service fuze, otherwise after a few days' drill they would be obliterated. The figures must naturally be opposite to the holes.

6. Over the holes a strip of black, red, or grey paper, with the dots at proper intervals corresponding to the holes, should be pasted.

7. Slips of paper 3 ins. long and ·25 in. wide, with dots ·25 in. apart (the top dot of even numbers ·25 in. from end of strip, and the top dot of odd numbers ·375 in.) should be provided, so that a fresh strip of paper can be pasted over the holes at the end of each day's drill.

8. The exact method of uncapping cannot be shown; for if the whole of the black wool (quickmatch) were exposed, it could only be done once at each day's drill. The following plan might, however, be adopted :—Six vertical strips of black or red paper (5 secs. or 9 secs. fuze) about half an inch wide and a trifle more than an inch in length, with a piece of white tape under each strip, might be pasted over the black wool. By this means the process of uncapping might be done at any rate six times for each fuze, and these strips replaced for the next drill.

103. The following table gives the calculated remaining velocity and energy, at various distances, of Palliser projectiles fired with battering charges of P. powder, from the 12-in. rifled M.L. gun of 35 tons.

Projectile, 700 lbs. weight; 11·92 ins. diameter; charge, 110 lbs.

Range.	v.	Total energy.	Energy per inch of shot's circumference.	Range.	v.	Total energy.	Energy per inch of shot's circumference.
yds.	ft.	ft. tons.	ft. tons.	yds.	ft.	ft. tons.	ft. tons.
0	1300	8205	219	2200	1094	5810	155
200	1277	7915	211	2400	1080	5660	151
400	1256	7655	204	2600	1068	5535	147
600	1236	7415	198	2800	1056	5415	144
800	1216	7175	192	3000	1044	5295	141
1000	1196	6945	186	3200	1032	5175	138
1200	1177	6725	180	3400	1022	5070	135
1400	1159	6520	174	3600	1012	4970	133
1600	1141	6320	169	3800	1002	4875	130
1800	1125	6140	164	4000	994	4795	128
2000	1109	5970	159				

W. H. N.

104. The following abstract shows the pressures observed from time to time during practice at Shoeburyness with the 12-in. rifled M.L. gun of 25 tons, Expl. No. 372.

Date of experiment.	Nature and weight of projectiles.	Charge and approximate muzzle velocity.	No. of round.	Pressure by crusher gauge in tons per square inch at A Axis, or end of bore.	B 12 ins. from end of bore.
22. 9. 71.	Com. shell, 495 lbs.	85 lbs. P. 1350 ft.	1	17·4	16·1
"	"	"	2	17·8	17·7
"	"	"	3	16·6	15·8
"	"	"	4	16·7	16·3
"	"	"	5	16·8	14·7
"	"	"	6	19·8	17·2
9. 4. 72.	Shrap. shell, 533·5 lbs.	55 lbs. P. 1100 ft.	1	12·8	11·7
"	"	"	2	13·5	13·6
"	"	"	3	12·2	11·7
"	"	"	4	11·6	11·9
20. 9. 72.	Case shot, 240 lbs.	85 lbs. P.	1	14·5	14·0
"	"	"	2	15·1	15·2
"	"	"	3	15·2	15·2

W. H. N.

MEMOIR

OF

MAJOR ROBERT WOLSELEY HAIG, R.A., F.R.S.

BY

MAJOR-GEN. J. H. LEFROY, R.A., F.R.S.

Robert Wolseley Haig, late Secretary to this Institution, was one of whom it is difficult for friends to speak without using language which may seem exaggerated to those to whom he was not personally known. His endowments of intellect were unusual; but those who admired his talents most, were in one sense least conscious of his superiority, because they had even more prominently before them that lovable simplicity of character, that inborn manliness, modesty, and humble estimate of himself, which is not always an attribute of genius, and which, when it exists, makes genius command lifelong affection. His character was as pure as it was elevated—full of playfulness, until bodily suffering laid its hand on him; but even then, brave, patient, and cheerful under it, submissive to that all-wise decree which cut so early the brightest ties of domestic happiness, and apparently unconscious how many would look long round the horizon of life before such another light to them would rise above it. He was, perhaps, one of the best mathematicians who ever entered the Artillery in the pre-competitive period. Applications of analysis were to him so easy, that he was hardly aware how exceptional his powers were; and they were at the service of all his friends, or at the command of the numerous committees with which he was associated from time to time, without a pretension on his part. They were never, indeed, adequately brought out; for as Astronomer of the North-West Boundary Commission, precise observation was more requisite than analysis; but if a question requiring the calculus of probabilities arose,* or some mechanical fact were wanted—such as the place of the centre of gravity of a solid of irregular form and density†—Major Haig was ready at once, not with a "practical" or tentative solution, but with a precise one; and he handled his integral tables as other people do logarithmic ones. It is to be regretted that he did not write more; but this was very much an effect of that total absence of pretension already remarked. His early contributions

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* See secs. 134–143 of Captain W. H. Noble's second Report on Ballistic Experiments. 1865.

† See Vol. VII. p. 212, where the determination in the note is Major Haig's, who however would not attach his name. 1871.

to the "Proceedings" of this Institution were of no great importance, and as Secretary his life was not spared long enough for him to impress, as he would have done, his character upon them; but those who had most to do with difficult questions in artillery between 1860 and 1870, best know how often his clear head and scientific attainments helped them.

Among other qualities significant of natural powers, he was a first-rate chess player—but so good-natured and unconscious that it was almost a pleasure to be beaten by him. The proximate cause of the lingering and fatal heart disease to which he fell a victim, was itself characteristic. He must needs enter for the "Veteran Race" at the Garrison Games at Woolwich, in 1868, and the over-exertion developed aneurism, the true nature of which was not detected in time.

Allusion has been made to his temporary employment on the Commission for laying out the boundary between British Columbia and the territory of the United States, under the treaty of June, 1846. Colonel J. S. Hawkins, R.E., the British Commissioner, has kindly furnished the following notice of this service:—

Major Haig left England with the Commission in April, 1858, and returned home with it in July, 1862, when he was employed upon the astronomical computations connected with the operations and the preparation of the boundary maps, until appointed Assistant-Secretary to the Ordnance Select Committee, in 1864. He had joined the Commission as Assistant-Astronomer, but on Colonel Hawkins' recommendation he was appointed Chief Astronomer, in which capacity he shewed a natural aptitude for the practical application of his very high mathematical talents, and for which appointment, in Colonel Hawkins' opinion, "no officer more competent could have been found throughout the services;" and as he also possessed health, strength, and energy, he was peculiarly well fitted for an expedition of the kind the Commission was engaged upon. When difficulties arose, he was always sanguine; and he impressed the same spirit upon the men under him, who were much attached to him, and willingly undertook whatever he required of them; while the energy he showed in everything which he entered into—whether shooting, fishing, canoeing, taking his turn with the axe, or the laborious duties which devolved upon him—the good temper and cheerfulness with which he bore hardships, and his unfailing high spirits and kindly nature, endeared him to all the officers of both the British and American Commissions.

Major Haig was appointed Secretary to the R.A. Institution on the 11th Dec. 1871, and performed his duties evidently under great bodily suffering (though he rarely complained) till the 6th June, 1872, when he was taken from the scene where it was hoped his eminent talents would have conferred great benefit on the Establishment which, by this brief memoir, records the loss it has sustained.

I. R. AUSTRIAN ARTILLERY FIELD EXERCISE,

PARTS III. & VII.

VIENNA, 1871.

TRANSLATED BY

LIEUT.-COLONEL W. H. GOODENOUGH, R.A.

WOOLWICH:
PRINTED AT THE ROYAL ARTILLERY INSTITUTION.

M.DCCC.LXXII.

TRANSLATOR'S PREFACE.

The issue of new exercise books for infantry and cavalry within the last three years, has made some of the movements prescribed in the "Field Artillery Exercise Book" of 1861 obsolete; it has also made more apparent than before, the want of proper provision for pliancy in manœuvring.

A long experience of field manœuvres of the three arms at Aldershot, &c., has given the writer ample proof that the existing field artillery drill has many shortcomings; it also suggested to him some improvements. The artillery service of Austria, from its strong *esprit de corps* and its conspicuous services, has a high reputation; the writer was therefore the more disposed to examine with interest the new "Austrian Field Artillery Exercise Book," published in 1871. He found in it, amongst much new matter, some of the alterations he had before thought of. The whole appeared to him well worthy the attention of his brother officers, and he now offers part of it for their perusal, in the confidence that, widely read and digested, what is applicable in it to our organisation will eventually be incorporated into our system of manœuvring.

It will be seen that the Austrians reduce the number of movements to a minimum, and make the requirements of service the guide as to everything that is to be taught. They adopt thoroughly the non-pivot system, with the division as the unit. The division officers are in their proper place to lead—namely, in the front. This also facilitates the use of signals (with the hand or sword, in aid of, or as substitute for, the voice) which, as in our navy, are freely introduced; they help to fix the attention on the commander, and obviate the noise and confusion resulting from unnecessarily loud words of command. The division of labour among the officers in action, and the arrangements for supply of ammunition, well deserve attention. It is to be remembered that the Austrian battery has but one line of wagons; the next reserve is the ammunition column attached to the army division to which the battery belongs. As the average expenditure of the batteries of a division together will probably never equal the maximum expenditure by one battery, this arrangement is economical, and as, compared with our present system, it diminishes the excessive augmentation required to put a battery on the war strength, it is practical.

In the "Austrian Artillery Exercise," published as it is in seven separate parts, there is a good deal of repetition. This is explained when it is known that the object was the very desirable one of making each part as complete as possible in itself, so as to avoid references to what has gone before, which are always a hindrance to the learner.

The excellent signal for *silence*[1]—or arresting of all movement—well known in navy gun drill, and to travellers by Indian troop ships, is one not found in the Austrian book; it is, however, much to be recommended for artillery, field and garrison.

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[1] Written before introduction of the sound "Stand fast."

CONTENTS.

PART III.

PART VII.

I. R. AUSTRIAN ARTILLERY FIELD EXERCISE.

PART III.

TRAINING WITH FIELD GUNS.[1]

CHAPTER I.

§ 1.

General Rules.

6.[2] All handling of material and movements are to be carried out with a lively and an unrestrained soldierlike bearing.

In action, however, the freest, easiest bearing possible must be allowed to the soldier, since upon this his endurance in the arduous work of serving guns depends.

12.[2] With the 4-pr. gun, the gun detachment consists of seven, with the 8-pr. gun of eight men. Their principal duties are:—

No. 1 carries a cartridge case, * * * adjusts fuze, and loads. This number should be, if possible, a *Vormeister* (*Munition's Vormeister*),[3] or at any rate a well trained and reliable man.

No. 2 * * * * * * sponges and rams home, and unloads the gun.

No. 3 has charge of the tangent scale and pricker, * * * pricks cartridge, serves vent, and lays gun. * * * * * * This man is the *Vormeister* of the gun, *who superintends and conducts the other numbers in their duties.*[4]

No. 4 has the tube box and tube lanyard; * * * with the 4-pr. he alone, with the 8-pr. he, in conjunction with 5, traverses. He fires. * * * * *

No. 5, with the 4-pr., has a cartridge case, and brings up ammunition; with the 8-pr., carries a handspike, assists 3 to traverse, and helps to limber-up and unlimber.

No. 6 looks after the battery ammunition wagon, and issues ammunition.

No. 7 has a cartridge case, helps to take ammunition out of wagon, in slow firing carries it to the gun, and is a reserve number.

---

[1] The following are extracts from Part III. of the "Artillery Exercise Book," which appear necessary to elucidate the battery drill.—Tr.

[2] The numbers 6, 12, &c., are those of the paragraphs in the original.—Tr.

[3] A superior class of gunner.—Tr.

[4] The passages in italics are thus distinguished in the original.—Tr.

No. 8, with the 8-pr., acts as does No. 5 with the 4-pr.

46. * * * * * * No. 3 (in laying) brings his better eye to the level of the notch on the tangent scale at a distance from it of about 6 ins., or more if far-sighted—at the most 12 ins.—and avoids lowering his head to one side.

* * * * * *

(After giving the elevation) he gives by signal with the left hand behind his back, to No. 4 (with the 4-pr., or No. 5 with the 8-pr.), the indications to correct the horizontal laying; No. 4 having previously of his own accord traversed into the approximate line. * * * *

73. * * * * No. 4 (after putting a tube in the vent and adjusting the lanyard), quits the tube and lanyard hook with his left hand, steps back three paces without bringing up the right foot, and then with his left arm straightened he stretches the lanyard rather downwards, so that the tube should not rise out of the vent. (When ordered to fire, para. 125) No. 4, *after satisfying himself that nobody is in front of the muzzle,* delivers with the inner side of the right hand a short blow on the stretched lanyard, and near his left hand.

CHAPTER II.

PREPARATORY EXERCISES WITH THE FIELD GUN, UNHORSED.

* * * * * *

§ 5.

Handling and Replacing Stores.

* * * * * *

85. *The handling and replacing the stores* is only a preparatory duty, but it must be carried out quickly and together, without, however, any formalities.

86. The division commander, after the men have been marched on the gun, gives the order for getting out the stores by the command—

"Handle stores."[1]

"Ergreift die Requisiten."

(Equivalent to our "Prepare for action," with heavy guns.—Tr.)

1 and 2 step to the muzzle, where the former unstraps the tampeon, takes it out, and makes it fast under the muzzle.

---

[1] I can find no command to "Prepare for action" in our field gun exercise, as there is in the exercise for heavy guns, but I think it would be useful to introduce it. If introduced, such a command would generally be given on hooking in, when the battery was parading for field exercise, and would be omitted when parading for route marching. At present there is nothing to prevent a battery of young soldiers from turning out without No. 5 having his tube pocket strapped on, or with the guns laid horizontally in the travelling position (when they are generally, for drill, required to be run up so as to be nearly horizontal when brought into action), and with boxes locked when they ought to be open, &c.

* * * * * *

No. 2 unstraps the sponge. * * *

No. 3 makes a whole turn towards the cheek of the carriage, unstraps the vent cover, leaving it hanging on the left side; then, by aid of the elevating screw, depresses the gun so that it should be nearly horizontal when unlimbered. No. 3 further takes out of the limber box a cartridge case, a knife, and a time fuze setter, and gives them to No. 4 (or No. 8 with 8-pr.); he also gives a tube-case, with lanyard and drill tube (or a packet of tubes if required), to No. 4, puts on the tangent scale and primer case, * * and shuts the limber box.

No. 4 goes to gun-limber and receives his stores from No. 3.

* * * * * *

88. When standing at ease for a long period, the stores can be laid aside by command.

89. To put away the stores, the command is given—

"Replace stores."

* * * * * *

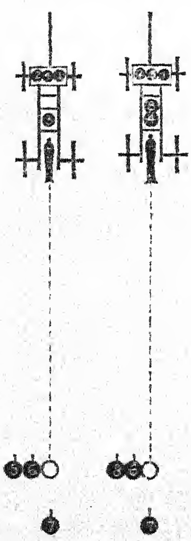
§ 6.

Mounting and Dismounting Detachments.

90. The detachments can be mounted or dismounted with or without stores. To mount, the command is given—

"Detachments, mount."

With the 4-pr., 1, 2, and 4 go to the gun, 5 and 6 to the wagon limber, 2 behind 4, and 5 behind 6.

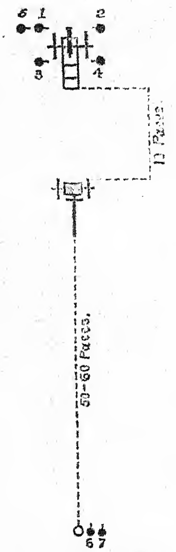


Gun Detachments mounted.

1, 4, and 6, according as they mount on the right or left side, seize with the left or right hand the guard iron of the limber box from above, place the opposite foot on the step, and mount on the limber.

2 and 5 mount after the other numbers in like manner.

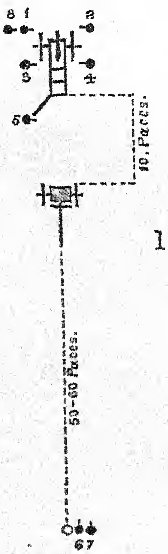
No. 3 goes to the trail, and mounts the seat thereon.



Normal Formation
with unlimbered 4-pr.

98. * * * * * *

This is called the normal formation with the unlimbered 4-pr.



Normal Formation
with unlimbered 8-pr.

103. * * * * * *

This is called the normal formation with the unlimbered 8-pr., when ready for action.

§ 9.

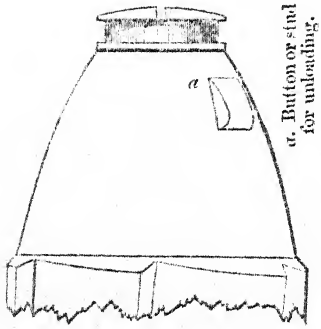
Unloading.

119. If it is requisite to unload the gun, the command is given—

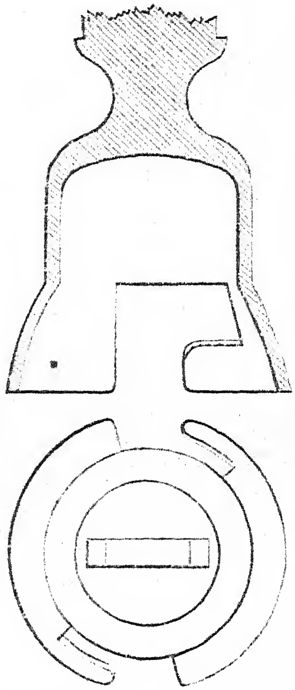
"Unload."

The friction tube is extracted by 4 from the vent. * * * *
Nos. 1 and 2, and with the 8-pr. No. 8, go to the muzzle, as in loading.

120. If it is a shell, a shrapnel shell, or a carcass which is to be unloaded, No. 2 enters the rammer into the bore, turns it from above towards his body, till the buttons on the head of the shot are got hold of, and by a gentle movement draws the shot out.



a. Button or stud for unloading.



Section of rammer head of galvanised iron.

121. The cartridge is extracted with the worm.
122. A case shot is extracted by sinking the muzzle or raising the trail.

* * * * * *

124. On real service, pricked full cartridges will be expended at the first opportunity, and pricked reduced cartridges (*Wurf patronen*) will be thrown away.

§ 10.

Opening and Ceasing Fire.

* * * * * *

129. If it is desired to cease firing, the commander orders in a prolonged tone—

"Cease firing."[1]

[1] The order to fire all guns that are loaded on the command "Cease firing," has always seemed to me an imperfect arrangement, and one which might at any time on service cause a disaster.

The unloading is facilitated by buttons on the shot head and a kind of bayonet slot in the rammer head. This slot, in driving home the shot, is used also to set the shot with its flanges against the driving side of the grooves. (See figure.)—Tr.

Whereon, if the gun is loaded, the friction tube is removed and the pricker inserted in its place; if the gun has just been fired, it is to be sponged out, and not loaded again, or the operation of commencing to load, if begun, should be arrested. All the numbers fall in to their places in the normal formation.

130. Before limbering-up, guns which are loaded must always be unloaded. (Paras. 119–124.)

* * * * * *

§ 12.

Replacing Casualties in the Detachment in Action.

134. *The Vormeister* of the gun will be replaced by the ammunition *Vormeister*, or, in his absence, by the smartest soldier. The reserve No. 7 takes the place of any other number. In the case of a further casualty, No. 5 with the 4-pr., or No. 8 with the 8-pr., takes his place, his duties being then taken by No. 1. No. 2 can help to traverse in place of No. 4 or No. 5, and No. 3 can enter the friction tube and fire. If only two soldiers are left, No. 3 does the duty of No. 1 in addition to his own, and No. 2 mans the trail handspike and fires.

At exercise, the replacing of casualties should be practised at the command—

"No. — disabled;" and at

"As you were,"

the normal formation should be resumed.

CHAPTER III.

Instruction of the Division with Guns horsed.

§ 14.

General Observations.

* * * * * *

140. * * * * * * In addition to the instruction for conduct in action, particular attention is to be paid to the movement from one position to another. In this the nature of the ground is always the chief thing to be considered.

The division commander must regulate the form of the movement and mode of formation of his detachment, according to his own judgment, and conformably to the ground. If the *commander* be personally prevented from reconnoitring the ground—as may, for instance, be the case in a retreating movement—*this duty should be delegated to a N.C.*

officer. It is consequently indispensable that the N.C. officers should be exercised in *estimating the nature of ground rapidly and correctly.*

Similarly, the *N.C. officers must be required* to be able quickly to discover suitable situations *for cover for the battery wagons and gun limbers,* and to take advantage of them *without first awaiting the directions of the commander, who is occupied with the general tactical relations* of his detachment.

* * * * * *

145. *All changes of formation* should, as a rule, be executed on the move. The division should, therefore, be ordered first to move off, and during the movement should receive the command for any alteration of its formation.

146. *At the commencement of a movement* each carriage should advance three paces straight to its front, and only after that begin any necessary wheels.

* * * * * *

148. *The walk* will be resorted to by all batteries in ordinary marches, or in lengthened tactical movements.

In manœuvring, 125 to 130 paces should be gone over at a walk per minute. The detachments with field guns follow the movement on foot, and at an increased pace. In marches, the pace is to be suitably diminished.

149. Within the actual sphere of the action, all batteries move, as a rule, at a *trot,* at the rate of 300 paces in a minute.

The trot is to be kept up, with foot batteries, for distances of a maximum of 2000 paces.

As a general rule, when within the range of the enemy's fire, the detachments of the foot batteries are to be mounted.

With dismounted detachments, foot batteries do not move at a trot for greater distances than 200 paces, at the rate of 250 paces in a minute.

* * * * * *

150. *The gallop will only be employed for the direct advance at full intervals into position*—with foot batteries, on very good ground, for not more than 500 paces; with cavalry batteries, up to 1000 paces.

The rate of movement is 450 paces in a minute; but with cavalry batteries, under urgent circumstances, on favourable ground, this may be somewhat increased.

Movement from a halt at the gallop is not permissible, and this pace is only to be ordered after the guns have accomplished a short distance at a trot.

* * * * * *

154. The division commander gives the commands to his division either *with the voice,* or by signals *with the sword.* He places himself for this purpose always at a reasonable distance—say 20 paces—from his division, where he can be heard and understood.

155. *The following signals with the sword are to be employed:—*

1. *The sword held perpendicularly, with the arm raised straight up,* signifies "March," or "Halt," accordingly as the detachment is halted or in movement.

2. *The sword held horizontally, with the arm stretched out forwards,* gives the directing N.C. officer the direction of movement. The commander must, in using this signal, *ride a few paces forward,* and point out exactly to the directing N.C. officer the new direction of the march, and must satisfy himself by a glance to the rear that the line of front is properly aligned. If one or other flank is too much retired or too forward, he must, whilst riding forwards, order, by waving his sword, the proper flank to increase or diminish its pace.

3. *For diminishing the rate* of movement, the sword must be brought up with a straight arm to the front, with edge downwards, and moved slowly round in a quarter circle towards the rear. This signal executed towards the right, signifies *the reducing the pace on the right;* if carried out on the left, *the reducing the pace of the left flank;* given on both sides, it denotes *the reduction of the pace of the whole detachment.*

4. *In order to bring one or other flank forward*—that is, to make it increase its pace—the sword should be brought up, edge downwards, with a straight arm, horizontally in line with the right or left shoulder, accordingly as the right or left flank is to be brought forward, and a quarter circle described forwards. This signal given towards both hands denotes *the increase of pace of the whole.*

5. *To open or close the intervals,* the sword is held up perpendicularly with a straight arm, and the point moved a few times downwards towards the right and left.

6. *To wheel,* the sword is to be moved as for the bringing forward of one flank, but almost in a half circle. For a wheel to the left, it should be swayed from the right rear over the horse's head towards the left; and for a wheel to the right, the converse.

7. *Reverse* is signified by raising the sword and arm perpendicularly upwards, and swinging it round two or three times in a circle.

8. In order to cause the *head of a column to change direction and march to where the commander is standing,* the sword is to be raised high in the air, and brought down slowly into the perpendicular position, point towards the ground.

9. *To form up in line at close intervals,* the commander moves at a rapid pace towards the side where the line is to be formed, and at least 50 paces ahead; he then turns towards his detachment, raises his sword with a straight arm into the line of prolongation of his shoulders, and parallel to the direction of the alignment; the edge of the sword to be downwards. The formation ensues in the direction of the point of the sword.

10. In order to *form line on the centre* (right and left of the front—Tr.), the commander rides forward to a sufficient distance in front of the centre of the head of the column, then turns and faces it, and points with his sword point, in the manner before detailed, towards the right and left.

11. *To form in line for action,* the mode in which the detachment is to form up is first to be indicated by signals 9 and 10, and imme-

diately thereupon, line for action ordered by the sword signal for "open intervals."

156. *The commander must, at the commencement of the instruction, always accompany the words of command with the corresponding sword signals.*

157. When the instruction is advanced, the *sword signals* alone are to be used. The commander may prelude these by the command "Attention," or the corresponding sounding on the trumpet. *Later on, even this call to attention is, as a rule, to be omitted. The sword signals alone will suffice for the correct handling of a well trained detachment.*[1]

158. In the training of the division, *the trumpet soundings*—which are only intended, however, for the exercise of larger detachments of field artillery—are to be practised exceptionally, merely for instruction.

159. The N.C. officers and men should thoroughly understand the trumpet sounds, and be able to sing or whistle them.

For the division, the following sounds apply (Part VI., Exercise Regulations) :—[2]

1. "Attention."
2. "Walk." "Trot." "Gallop."
3. "To carry out an order" (*Ausführung*), or "March."
4. "Halt."
5. "Reverse."
6. "Fire." "Cease firing."

   "Fire," blown once, signifies battery-fire; blown twice, it signifies the opening of independent firing.
7. "Call" (*Apell*) for calling in the ammunition reserve. Blown twice, this signifies "Reverse front to the rear."
8. "Mount" and "Dismount," when the mounting is general.

§ 15.

Formation of the Division.

165, 166. * * * * * *

167. * * * * * The two horses of each pair must stand on a level. The traces may hang down loose, about a hand's breadth below the straight line of draught.

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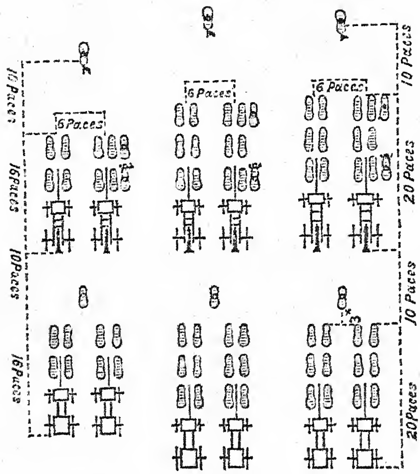
[1] In the Austrian cavalry the command, or signal, "Attention" always precedes any other command. In cavalry and artillery such command is not carried out till the executive sound, command, or signal, "March" is given. This is of much advantage, particularly during rapid movement. The sequence would thus be, for instance, "Attention," "Divisions—Right Wheel," "March." Commands thus given can seldom be misapprehended.—Tr.

[2] The only sound of general application used in Austria which we have not, is that of "*Abblasen*," used for discontinuing an exercise, &c.,—"knocking off." I have generally heard the retreat or assembly used with us for this, but neither are quite applicable.—Tr.



4-pr. foot. Cavalry. 8-pr. foot.

Divisions in the Normal Formation.

Explanation.

Gunner. Corporal.
Trumpeter. Division Serjeant.

Division Commander.

168. Of officers and N.C. officers, there are with each division one officer, cadet acting lieutenant, or staff serjeant, as commandant, one division serjeant, and one corporal.

* * * * * *

172. Wherever field guns are employed, it is a principle that a part of the ammunition supply is always to be kept, as far as possible, out of the range of fire. The division commander, to this end, before the commencement of the exercise, details a battery ammunition wagon as ammunition reserve, which has to follow the division at a distance of 500 or 600 paces, under the command of the N.C. officer attached to the wagons. The other wagon remains close up to the guns, in front or rear of the gun No. 1, and in action is to be placed, covered as far as possible, 50 or 60 paces to the flank and rear of the guns.

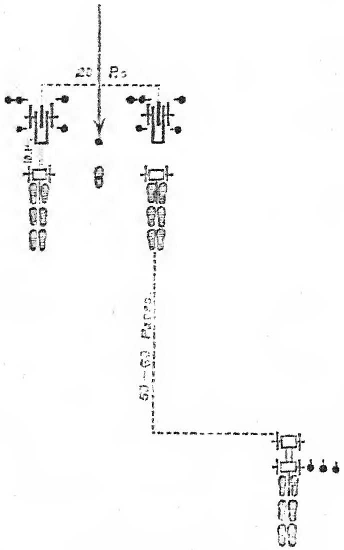
173. The ammunition reserve of the division has always to select in moving the shortest lines whilst taking advantage of cover. In taking position, it should, without troubling itself too anxiously about its correct distance, select places affording cover.

The two Nos. 7 of a division are to place themselves side by side with the ammunition reserve. In rapid movements they sit on either side of No. 6, on the wagon limber.

* * * * * *

186. *The line at close intervals* is only permissible for manœuvring out of fire. Within the effective range of fire (2000 paces) its use is to be, as much as possible, avoided.

236. * * * * * *



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* * * *

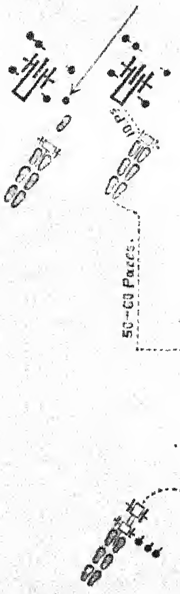
(Text omitted.)

The Division in Action.

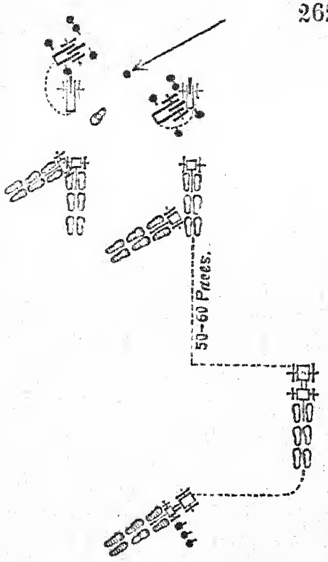
§ 26.

262. If during the action a change of direction of fire should become necessary, it is effected by throwing round the trails.

The division commander names the new object of fire, the distance estimated, the projectile, and description of fire, and the division serjeant superintends the opening of fire in the new direction.



Change of Direction of Fire.



Change of Direction of Fire, by shifting Guns.

263. When the change of direction is considerable, and there is a want of good cover, one or other gun will be run forward or back, according to the judgment of the commander, by the gun detachment; the teams will be brought into the prolongation of the direction of the enemy's fire, so that casualties may, as much as possible, be avoided.

*   *   *   *   *   *

§ 27.

Replacing Ammunition.

271. *To replace the ammunition expended out of the gun limbers,* the battery ammunition wagon goes forward at the command of the division commander, at a trot, towards the guns, and places itself, by means of a double wheel, between the two limber teams. The ammunition carriers rapidly make good the ammunition expended out of the gun limbers, and the battery wagon returns to its previous position at a trot.

Under pressing circumstances, where a speedy completion of the ammunition is necessary, the limber of the wagon may, on its arrival at the guns, be exchanged with a gun limber.

272. *Any wagon which is emptied after thus supplying requirements,* goes back at a trot to the ammunition reserve. The wagon detailed as ammunition reserve will then be brought back at a trot by the N.C. officer to the proper place near the guns, and the fact reported to the division commander.

The N.C. officer afterwards takes the empty wagon rapidly to the ammunition park, and after completing with ammunition, returns without delay, and reports his return to the ammunition reserve to the division commander.

§ 28.

Replacing Casualties among the Men.

273. The replacing casualties among the detachment is effected according to para. 134.

274. For casualties among the drivers, the wheel driver is to be replaced by a driver, the centre or lead driver by one of the gunners.

275. According to circumstances, the centre drivers, or, in case of need, the leading drivers of 4-horse teams, may be employed in carrying ammunition.

PART VII.[1]

TRAINING AND COMMAND OF BATTERIES.

CHAPTER I.

Regulations for a Single Battery.

Section 1.

Introductory Principles.

§ 1.

General Remarks.

1. The battery forms the tactical unit of field artillery. It forms a complete whole in itself, and even in combination with other batteries is moved as a self-dependent body.
2. The battery is divided into four divisions (*Geschützzüge*), two of which form a half battery.
3. The training of a battery is based upon the principles and formal regulations laid down for the instruction of a division (of two guns).
4. A half battery or a battery, on the peace strength, is exercised according to the regulations for a battery. The former is addressed with the command "half battery," the latter with the command "battery."
5. All specially requisite instructions are given under the respective heads.

§ 2.

Duties of Officers and N.C. Officers, and of the Commander.

6. Commanders conduct and command their detachments according to the following regulations. Under all circumstances they remain responsible for their commands.

In all movements the single divisions are commanded, within certain bounds, independently, and here the regulations for command of the division have their application.

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[1] Many paragraphs of minor interest have been omitted.—Tr.

The serjeants of divisions (*Zugs Führer*), who are placed on the flanks, are charged with maintaining order in the divisions.

7. The *commanders of divisions* convey the orders they have to give, in fulfilment of those received from the commander of the battery, by signals with the hand—analogous to the signals with the sword—combined with a corresponding turning movement of their horses and adoption of the required pace. In case of need, they can leave their assigned stations, and place themselves wherever required to superintend their detachments.

   Under peculiar circumstances, the division commanders may communicate their orders with the voice, but never louder than necessary.

8. The conduct and command of the battery ammunition wagons devolves on the corporals attached to them; they observe in this respect the same directions as given for division commanders.

9. The duty of the *commander of the ammunition reserve* will be treated hereafter.

10. The *battery commander* is not obliged to keep to any particular station when commanding his battery, but should move to wherever he can judge of the progress of the action, overlook the ground and observe the effect of the fire, and exercise the best control over his battery. He must not, however, occupy himself with detail, but should direct his attention to the whole.

11. Should the battery commander have to betake himself so far from the battery that his orders or sword signals cannot be understood, then the next senior officer, without further intimation, should take up the executive command.

12. When a *division commander* is detached from immediate connection with his division, then the division serjeant takes up his duties *ad interim*, and the place of the latter remains unoccupied.

13. If the battery commander desires to instruct his battery, or to observe its proficiency in training, he causes himself to be replaced in the executive command in the front by the next senior officer, who then gives the words of command according to his directions. The battery commander may then place himself on the flank or in rear of the centre of the battery.

14. When the battery is split up, the battery commander accompanies, when not otherwise ordered, the larger fraction. If a half battery is detached, it depends on the importance of its intended employment whether the battery commander should accompany it or remain with the other half battery.

15. The senior *battery trumpeter* attaches himself at the commencement of the movements to the battery commander, and keeps on his flank and rear in such manner that he can take up his orders.

    The second battery trumpeter is attached similarly to the commander of the ammunition reserve.

§ 3.

Commands, Signals with the Sword and with the Trumpet.

16. The movements of a battery, whether acting alone or with others, are

directed by words of command, or by the signals with the sword, as laid down for the instruction of the single division.[1]

17. When a single battery is attached to other arms as a self-dependent body, the battery commander may, exceptionally, employ the *signals with the trumpet*, as laid down for the single division. The greatest caution must, however, be always observed herein, so as to avoid misunderstanding with the other troops.

18. If the battery commander gives his *commands with the voice*, he must deliver them in the form of a caution and an executive command, and must divide the latter by a slight pause, so as to give time for reflection to those who have to carry them out. He must also utter the command clearly and intone it properly.

The elevation of the voice should be regulated by the rapidity of the movement, and by the outward circumstances which may tend to interrupt the sound.

To deliver a word of command, the battery commander either turns in the saddle, with his face towards the battery, or places himself directly facing it.

19. If he wishes to command by *sword signals* alone, then these should, as far as possible, be delivered at the halt, front to the battery, from the proper place, very clearly, intelligibly, and slowly, so that they can be rightly understood by the division commanders. *The battery commander is always to keep at a proper proportionate distance from the battery.*

§ 4.

Paces.

20. The work of field artillery in respect of mobility often requires speed and endurance. The success of its undertakings is consequently dependent on the capacity for work of its horses. These, therefore, must be spared exertion as much as possible, but in decisive movements they must be worked up to the extreme of their powers.

21. The regulations for the employment of the paces laid down for the single division, apply also to the battery.

22. A battery working in intimate combination with another arm, keeps to the pace and rate of movement (*Tempo*) prescribed by these circumstances. When working independently, the battery commander regulates the pace of his battery according to the general rules already laid down, and with reference to the pressing character, or otherwise, of the object in view, and to the distance to be traversed.

The commander of a battery attached to cavalry must take into consideration the rapidity of movement of this arm, in order not to incur the danger of reaching the scene of his action too late, and so missing the favourable moment for taking part in the engagement. This consideration, however, must not betray the commander into over-exerting his horses; for the use of a battery is lost if the teams, prematurely exhausted, are unable to continue to keep up with the movements of the cavalry.

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[1] See the extracts from Part VI., at para. 159 preceding part.

23. For the mounting of the gun detachments, the regulations for the single division remain in force.

§ 5.

Formation in Line.

24. In *line*[1] (*entwickelte linie*) the divisions forming the battery are placed side by side. In the normal formation (called *Grundstellung*) they stand from right to left in the order of the numbers which they bear in the internal organisation of the battery.

25. In the course of movement, the divisions, standing by one another, will be named or addressed by the battery commander according to the station *which they hold in the battery at the moment.*

The division on the right is called *"right flank division,"* that on the left, *"left flank division;"* that on the right of the centre, *"right centre division;"* that on the left of the centre, *"left centre division."* The two divisions on the right flank are called *"right half battery;"* the two others, *"left half battery."*

On the other hand, the division commmanders, whenever necessary, always address their divisions according to their proper numbers (as, *e.g.*, *"first division."*) The guns are numbered from the right flank.

26. When retiring (wagons in front),[2] the flanks, divisions, half batteries, and guns retain their original appellations.

27. The *ammunition reserve* of the battery consists of four battery ammunition wagons. The battery commander details for this employment the ammunition wagons of a half battery, which at the commencement of the movements remain behind, and are brought on after the battery according to the provisions of § 21. (See p. 45.)

With a half battery, the two battery ammunition wagons of a division are similarly detached as ammunition reserve.

28. *To replace casualties* there are attached to the ammunition reserve a reserve detachment of 1 corporal and 16 gunners (in excess of the regular strength of the gun detachments). To the ammunition reserve are attached also the drivers attached to the N.C. officers' horses, and the whole of the reserve horses, with their harness. The reserve detachment (*Ersatz abtheilung*), as well as the reserve horses, follow the ammunition reserve, but can be brought up to the ammunition wagons with the battery at the discretion of the battery commander.

29. The four battery ammunition wagons which follow the battery immediately into action, stand in line in rear of the half battery forming the right wing. When reversed, they remain in the same relative situation.

The battery ammunition wagons of a half battery stand in rear of the right flank division.

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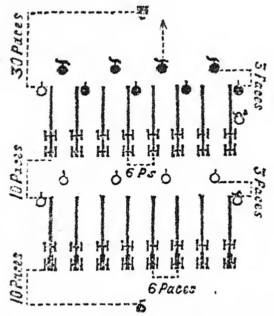
[1] The ordinary "line" is formed with intervals of six paces from muzzle to muzzle; the line for action (*Feuer linie*) with (normal) intervals of twenty paces.—Tr.

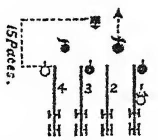
[2] Retiring from "line" at close intervals is effected by wheeling the half batteries twice to the left, bringing the wagons in front. Retiring from line for action (full intervals) is effected by wheeling each carriage about on its own ground.

The battery ammunition wagons carry out the necessary movements in conformity with those of the battery, yet preserve a certain independence.

30. The posts of officers and N.C. officers, &c., in the normal formation, may be seen in the figure adjoining.



Battery in Normal Formation.



Battery in Peace Formation.

Explanation.

Battery Commander.
Division Commander.
Staff Serjeant.
Division Serjeant.
Corporal.
Trumpeter.
Horsed Guns.
Horsed Battery Ammunition Wagon.
Direction of March.

31. The *battery commander* places himself at a proportionate distance in front of the centre, and betakes himself always to wherever he considers his presence necessary.

The *division commanders* place themselves three paces in front of the centre of their divisions, facing to the front. The upper lieutenant commands the first, the senior lieutenant the fourth, the third officer the third, and the cadet acting lieutenant (*Cadet offizier's Stellvertreter*) the second division.

The *staff serjeant* stands ten paces behind the centre of the battery ammunition wagons, facing to the front, and superintends them.

The *division serjeants* place themselves by the off-lead horses of the right guns of their divisions.

Four corporals are attached to the battery ammunition wagons, and are placed one before the wagons of each division, in corresponding positions to those assigned to the division commanders.

A *corporal* is on the left flank of the guns, and another on the left flank of the wagons, next the leading drivers. The former is intended for employment in manœuvring as an orderly,[1] and must therefore be an efficient and well mounted man. During the exercise of the single

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[1] This corporal is, in army manœuvres, detached to the commander of the artillery, and conveys most frequently *written* instructions. Officers are not employed in this service, as usual with us, and indeed they are too valuable.—Tr.

battery he should be attached to the ammunition reserve. The second corporal is attached in manœuvring to the commander of the ammunition reserve for like employment, as orderly.

In marching past, or in route marching, both corporals remain in the stations allotted them in the normal formation (para. 30). Besides these, no N.C. officers are to be employed as orderlies.

The *senior battery trumpeter* stands one pace in rear of the division serjeant of the first division; the second battery trumpeter, next the off-lead horse of the first wagon.

The *reserve detachment*, formed in two ranks, stands three paces behind the right flank of the battery ammunition wagons.

The *reserve horses* form in one rank, six paces from the left flank of the reserve detachment, dressed on the front rank. The *corporal with the reserve detachment* places himself on the right flank of the reserve horses.

With a *battery on the peace formation*, the supernumerary N.C. officers stand ten paces behind the guns in one rank, dressed from the right flank of the battery. The unattached gunners, in two ranks, form themselves on the left of the N.C. officers at six paces interval, the front rank dressed on the heads of the horses. At exercises and manœuvres, the ammunition wagons[1] with the battery are to be marked by two N.C. officers, a third exercising the command; the staff serjeant with two other N.C. officers, mark the ammunition reserve. The first stand ten paces in rear of the right flank division, in the proper place of the two battery ammunition wagons; three paces in front of their centre stands the N.C. officer commanding. During movements, both remain in the relative situations as hereafter laid down for the battery.

32. As soon as the ammunition reserve is detached, the staff serjeant, as a rule, takes charge of it. It remains, however, at the discretion of the commander of the battery, under circumstances of particular importance, to give the command of the ammunition reserve to an officer. The staff serjeant, in such case, replaces the division commander.

33. *In turning out the battery*, one officer conducts the gun detachments and one the horses to the gun park. The former are formed in rear of the guns, the latter ordered to hook in. The third officer forms with the horses, the cadet acting lieutenant with the detachments.

34. After hooking in, the division serjeants cause the drivers to mount, and report to the division commanders the strength of their detachments according to the numbers of men and horses.

35. The division commanders march the detachments on the guns, salute, without drawing the sword, and report to the battery commander the guns turned out, and go to their places.

36. The battery commander rides down the front, satisfies himself of the regularity of formation of the battery, specifies the allotment of duties in action of the several division commanders,[2] tells off the battery ammunition wagons for the ammunition reserve; then, according to

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[1] The battery on peace formation has four guns only, and no wagons.—Tr.

[2] See sec. 4, p. 38.

discretion, orders the handling of the side-arms,[1] and with cavalry batteries causes the detachments to mount.

§ 6.

Mounting and Dismounting.

37. Mounting and dismounting takes place according to the regulations for the single division. The commanders, &c., in the front mount and dismount in their respective places.

§ 7.

Dressing.

38. The *line of dressing of a battery* is at all times regulated, as regards the guns, by the division commanders; as regards the wagons, by the corporals placed in their front.

The battery commander effects the dressing of his battery on a particular line only through the medium of the commanders placed before the front of the battery.

Consequently, the division serjeants must take their distance of three paces from them, and see to the forming up of their guns. The leading drivers with the wagons form in like manner with respect to their corporals.

39. For the *correction of the dressing* in a given formation, the command is given—

"Right (left) dress."

Whereupon the commanders before the front turn the heads to the side named.

The battery commander goes a few paces beyond that flank towards which the dressing is to ensue, places himself in the line of dressing, and brings the commander of the division nearest him into the contemplated or given line of dressing; the remaining division commanders dress on these two.

In each division the division serjeant takes his distance from the division commander, and brings his guns into the required positions.

The battery commander satisfies himself, without spending unnecessary time and trouble on the correction of single guns, that the line indicated is correctly taken up, then similarly effects the dressing of the ammunition wagons, and commands—

("*Habt—Acht,*") "Attention," or "Eyes front."

Whereupon all again look to the front.

40. *To dress forward into a given line,* the battery should be led forwards a proportionate distance, halted a few paces in rear of the intended line, and dressed up according to para. 39.

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[1] In the Austrian service, the gunners go into action holding the side-arms, sponge, &c., in their hands when mounted. The handling of side-arms and small stores includes running down the elevating screw of the gun, and in every way making ready for immediate action; the ordering this latter as a special command is convenient.—Tr.

41. In *parade formations* the battery commander may adopt any measures he may deem necessary to attain a perfect dressing, and may even cause the dismounted gunners to man the wheels for this purpose.
42. The rectification of the front line by reining back the horses is, as far as can be, to be avoided.

Section 2.

Movements in Line.

§ 8.

March to the Front.

43. In the march in line, whether advancing or retiring, the commander of the right centre division for the time being, gives the direction, and he must choose a point to march upon, if none such is prescribed to him.
44. If the battery commander wishes to assign the direction to another division, he gives the caution, according to para. 25—

"— Division direct."

45. On the command—

"Battery—(Walk) Trot—march,"

the battery moves off together.

The officer charged with the leading must maintain a correct and even pace. He may precede the line by a little, but must never drop back. In other respects he behaves as ordered for the single division. The other division commanders dress on the division commander who is leading, and must preserve accurately their respective distances.

Every gun should move straight to its front, and thus obviate any swaying of the whole line.

The flanks may, if anything, hang back a little, but they should never press forward. Errors in the line are never to be corrected suddenly, but always gradually.

Those in charge of the ammunition wagons cause them to follow the guns at the prescribed distance.

46. When the ammunition reserve is detached, the wagons with the battery follow the right half battery; in retiring they precede it.

With a half battery, the two battery ammunition wagons preserve a similar station, in rear or in front of the right flank division.

47. Obstacles met with in the march which cannot be crossed directly by the carriages, are, under the guidance of the officers riding before the front, to be circumvented, and the previous formation resumed afterwards.
48. To stop the movement, the command is given—

"Battery—Halt."

Whereupon, according to the driving instructions, the pace is arrested gradually, till all stand steady at the halt.

49. The march in line towards the rear, after reversing the front, is carried out with observation of the same rule.

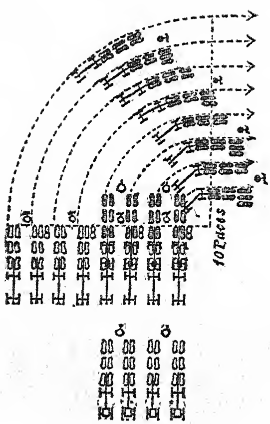
The battery ammunition wagons preserve the direction for themselves in their station in front of the guns. The battery commander names at discretion one of the corporals to "lead," and in every case indicates to both lines the common point to be marched upon.

50. In other respects the directions for the single division are observed.

51. *The march in line upon a particular point is the most important movement of field artillery, and must therefore be practised in all the paces, and over as long distances as practicable.*

§ 9.

Wheeling.



(At close intervals.)
"Right wheel."

52. In order to wheel, the battery commander gives the command—

"Right (left) wheel."

The division on the pivot flank wheels according to the directions for the division, and at the order of the battery commander—

"Forward,"

moves on to its front.

The other divisions wheel, led by their commanders, at a trot, keeping the prescribed interval from the pivot flank, until they arrive to where the direction of the march is straight forwards.

The division on the wheeling flank must, at commencement of the wheel, move for a proportionate distance straight forward, and thus obviate a dangerous lessening of the intervals.

The division commanders look generally to their front during the wheel, and only from time to time towards the pivot.

The battery commander gives the word "Forward" at that moment when the pivot division has arrived at a horse's length from the new line of direction. The other divisions, during the wheel, hang back rather slantingly, and after the pivot division has terminated its wheel, they continue their increased pace till they come up into dressing.

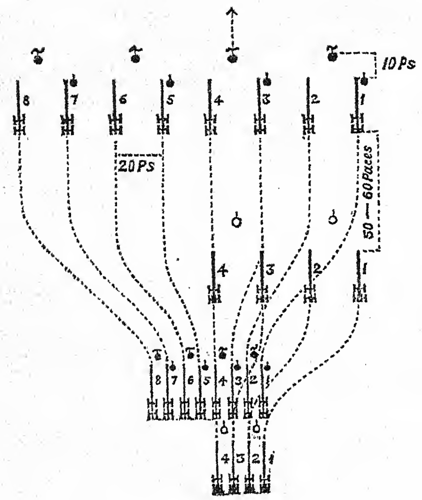
53. The battery ammunition wagons wheel on the same circle, and observe the same rules, as the guns in their front. In order to make a correct wheel, they should follow the guns closely till they close on the pivot, taking care at the commencement of the wheel to bear off about a gun's interval towards the wheeling flank.

54. In the line at full intervals no entire wheels are to be executed.

§ 10.

Increasing and Diminishing Intervals.

55. Opening out and diminishing intervals is effected, as a rule, on the right centre gun of the battery. If the battery commander wishes to effect it on any other gun, it has to be named.



(From close intervals.)
"Form line for action."

56. On the command—

"Form line for action,"
("*Feuer linie,*")
"Line for action on the — gun,"
or "Line for action at — paces interval," (Line for action on the—gun at—paces) "March,"

the division concerned takes the new interval; when the movement is a walk, that pace is continued; from the trot, on the other hand, the walk is assumed. The other divisions wheel at a trot by the shortest line into their new stations, increase their intervals away from the division which is continuing the direct march, and take up the walk on arriving in the line.

57. The battery ammunition wagons take a distance of 50 to 60 paces, remain in this relation to their half battery (para. 46), and open out simultaneously to the same intervals as the guns.

58. To close the intervals, the command is given—

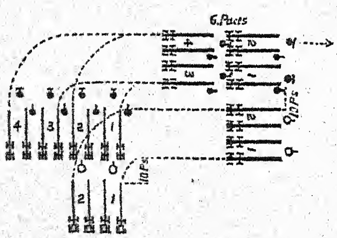
"Close intervals;" or,
"Close intervals on the — gun." "March."

The division concerned closes its intervals according to the known regulation. The remainder are brought at a trot by the shortest line into their new stations, and then take up the walk. The battery ammunition wagons take the proper distance, and close their intervals uniformly with their half battery.

59. In a confined space, the opening and closing of intervals is effected by aid of the flank march, the division commanders commanding under the directions of the battery commander.

§ 11.

March to the Flank.

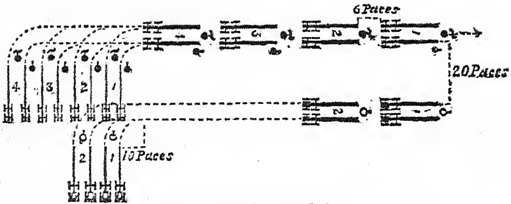


(From close intervals.)
"Flank march to the right."

60. From the line (ordinary, at close intervals—Tr.), the flank march is carried out on the command—

"Battery—Flank march (by divisions) to the right (left)."
"Walk (trot), march," or "March."

In the former case, the half batteries wheel simultaneously; in the latter, however, the divisions wheel in succession as they obtain room,



(From close intervals.)

"Flank march by divisions to the right."

and move in the prolongation of the front towards the flank named.

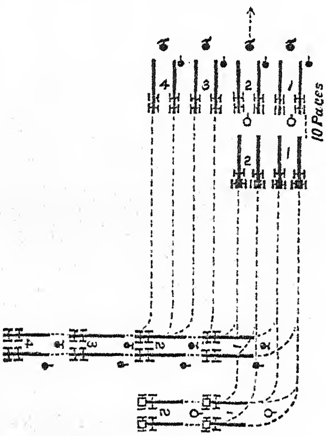
The battery ammunition wagons wheel simultaneously with, and in same manner as, their half batteries.

61. The wheel being terminated, on the command from the battery commander—

"Forward,"

the march is continued straight forward.

62. The direction of the march is given by the commander of the leading division on the side next the proper front, and all the other division commanders preserve their distances and intervals from him.



(From the flank march.)

"Left reform line."

63. To *reform the line,* the command is given—

"Battery—Left (right) reform line."
"Walk (trot)—march," or "March."

Whereon the several detachments wheel up at the prescribed intervals towards the front or towards the rear, and on the command—

"Forward,"

again move straight to the front.

64. *The flank march from the line at full intervals for action* is effected on the command—

"Battery—Flank march to the right (left)."
"Walk (trot)—march," or "March."

Whereupon the carriages make simultaneously an entire wheel to the named flank, and upon the command—

"Battery—Left (right) reform." "Walk—march," &c.,

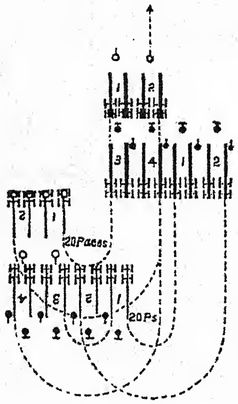
they reform either to the front or reversed facing the rear.

§ 12.

Reversing the Line.

65. The *reversing or reforming of the line* is effected in the line at close

intervals by the double wheel of half batteries, but in the line at full intervals by the double wheel of the single carriages.



(From close intervals.)
"Battery—Reverse."

66. *To reverse the line with close intervals*, the command is given—

"Battery—Reverse."
"Walk (trot)—march," or "March."

Each half battery, and the battery ammunition wagons, perform simultaneously a double wheel to the left, and on the word

"Forward,"

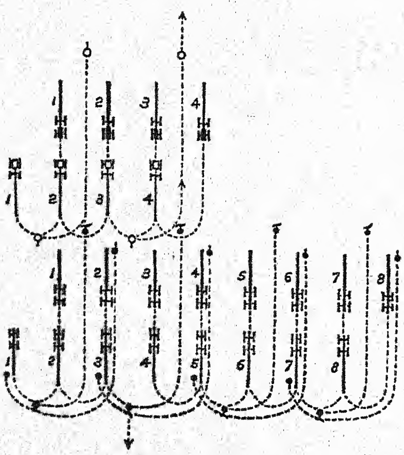
from the battery commander, continue the march in the new direction, or are ordered—

"Halt,"

when they remain stationary.

67. For the correct carrying out of the double wheel, the pivot gun of the left half battery must move forward at an animated pace, and the wheeling flank of the same must, at the commencement of the wheel, move straight forward for a few paces. Otherwise, the movement is conducted as in § 9.

68. The *reforming of the former front* is effected in a similar manner.



(From line for action.)
"Battery—Reverse."

69. To *reverse or reform the line from line at full intervals*, the command is given—

"Battery—Reverse."
"Walk (trot)—march,"
or "March."

The divisions are moved according to the regulations for a single division.

70. The officers in front turn in their own persons, allow the drivers to

carry out the movement before them, and then hasten to their places in front of their divisions through the intervals. The division serjeants move during the reversing to the right guns of their divisions, coming up behind their wheels.

71. In exceptional cases, the reversing and reforming the line can ensue by the command—

"Battery—Right reverse." "Walk," &c.

Section 3.

Formation, Movement, and Deployment of the Column.

§ 13.

General Remarks.

72. A battery can form three descriptions of columns—viz. :—

(*a*) Column of route.
(*b*) Column of divisions.
(*c*) Column of half batteries.

In the *column of route* the single carriages follow one another at five paces distance; in the *column of divisions* the divisions, and in the *column of half batteries* the half batteries, follow one another at ten paces distance. The battery ammunition wagons form similarly in rear of the guns; in the case of the formation of the column with the front reversed, they precede the guns.

73. Either column can be formed on either flank or on the centre, from the halt or during movement, and in like manner can be deployed.

74. With a half battery, or a battery in the peace formation, the column should always be formed on one flank, and the formation of line (from column) should be effected in a corresponding manner.

75. In the formation and deployment of columns no respect is to be paid to the position or numbers of the guns or of the wagons, as to their normal formation (*Grundstellung*). Nevertheless, the two guns of a division are not to be separated, nor are the two wagons belonging to one detachment.

76. The detachments of carriages will be addressed by the battery commander, according to their order of succession from front to rear of the

column, as "first," "second," &c., gun (battery ammunition wagon), or "first," "second," &c., division or half battery.

77. *In the formation of the column from the halt,* the several detachments take up the movement at the required pace one after another, as they get room. If the column is to be formed on the move, the detachment forming the head of the column retains its original pace, or adopts that which is ordered. The other detachments halt and range themselves behind the head of the column successively in their order.

78. In the *forming line from column from the halt,* the head of the column moves straight forward at the pace ordered, and will be ordered to halt at the discretion of the battery commander. The other detachments move up at the pace ordered into their places in line.

Forming line on the move is always to be done at the trot. If the battery was moving at that pace, then the head of the column drops into a walk.

79. The battery commander should order the pace at which the guns should move up into line according to circumstances.

80. *After forming line* no time is to be spent over a rectification of the front. The division commanders must comprehend correctly the main line of the formation, must judge accurately the space they require in which to form up, and must lead their detachments by the shortest way into the new front.

81. The division commanders ride, in *the column of route,* on the side of the original front; in a column formed on the right flank, or on the centre, five paces on the flank of the leading driver; in a column formed on the left flank, five paces on the flank of the division serjeant of the leading gun of their divisions. The division serjeants place themselves always beside the off-leader of their leading gun. The corporals with the ammunition wagons place themselves similarly to the division commanders.

All the officers and N.C. officers betake themselves, during the formation of the column only, to their new places. On a reverse of the column of route, they place themselves in their new stations by riding to the front. The division commanders and corporals remain on the side of the original front.

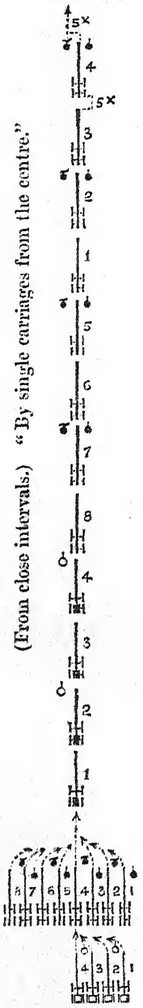
82. In the *division* or *the half battery column,* all officers and N.C. officers retain their places.

83. The march in column demands well considered practice, in order that the battery may become accustomed to the maintaining an even pace at a walk and at a trot. Long marches in column on level ground, and also on ground which is broken with obstacles, furnish the means for this practice. Nevertheless, at these practices no more is to be demanded in respect of dressing and of covering than the ground will admit of, or than can and must be demanded in reality.

§ 14.

Column of Route.

I.—Formation.



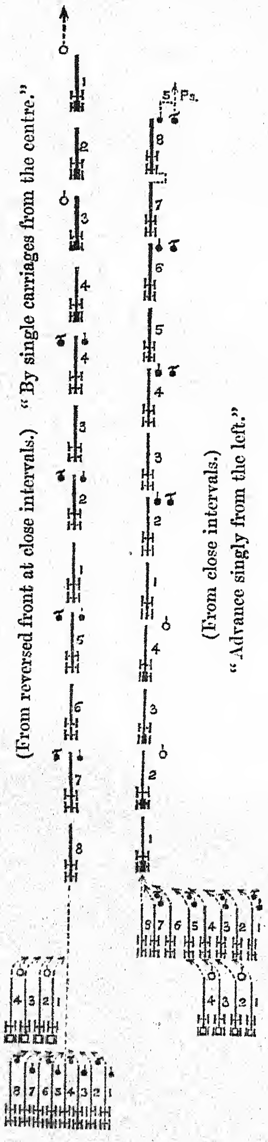
(From close intervals.) "By single carriages from the centre."

84. The column of route is usually formed on one of the flanks, but exceptionally also on the centre, and is only used in route marching, on narrow roads, or for the passage through confined spaces—never, however, as a formation for manœuvre.

85. For the *formation of the column of route on the centre*, the command is given—

"By single carriages from the centre."
("*Einzeln nach der Mitte.*")
"Walk (trot)—march," or "March."

The right centre division commences the movement according to the regulation for the single division, marching off left to the front. The right flank division follows, marching off by its left; then the left centre division, and afterwards the left flank division, marching off by their right. The battery ammunition wagons form the column of route similarly to the right half battery.



86. *From the reversed front* (para. 26), the battery ammunition wagons advance from their right and in front of the guns, and behind them the left centre division, marching off by its left. The left flank division follows, marching off by its left, then the right centre division and the right flank division, marching off by their right.

87. *For the formation of the column of route* on a flank, the command is given—

"Advance singly from the right."
("*Einzeln rechts vorwärts.*")
"Walk (trot)—march," or "March."

The divisions, and then the battery ammunition wagons, march off according to their order from the designated flank, according to the provisions of the regulation for the single division.

From the reversed line, the column of route (para. 72) is similarly formed.

II.—Movement.

88. The commander of the division at the head of the column *leads* towards the point he has chosen, or that which has been indicated to him.

89. The *reversing or reforming* the column of route follows on the command—

"Battery—Reverse—March."

at which all the carriages execute a double wheel to the left, and then continue the march straight forward.

90. With a reversed front, the corporal with the first battery ammunition wagon leads and gives the direction.

91. During the march, or in narrow and bad roads, the officers, &c., ride in front of their carriages.

92. In further respects, the regulations for the division are to be followed.

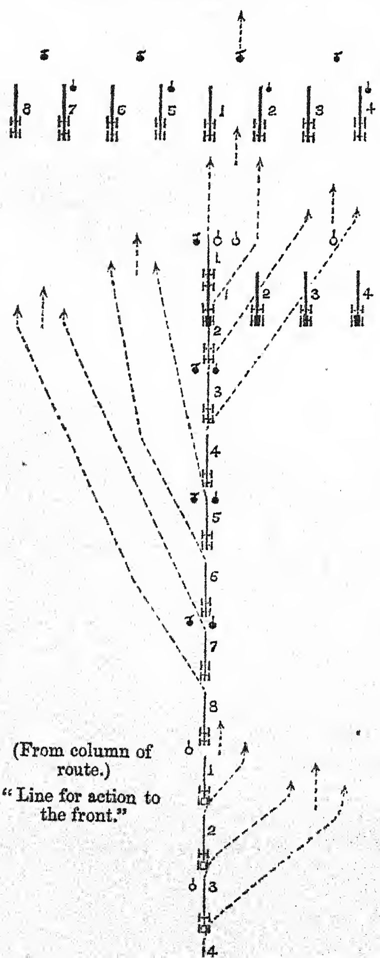
III.—Forming line.

93. *Forming line from column* is prepared for by the preliminary formation of divisions.

94. The commander of the battery places himself, in general, opposite the centre of the new line.

95. The commanders of divisions dispose themselves, according to the command of the battery commander to form line, by riding in front of their divisions; they form these latter, and then lead them into the new line. The intervals are always to be taken in the direction of the flank to which the battery is formed.

The division serjeants resume, at the commencement of the formation, where necessary, their places on the right of their right guns; the corporals with the battery ammunition wagons do the same as the division commanders.

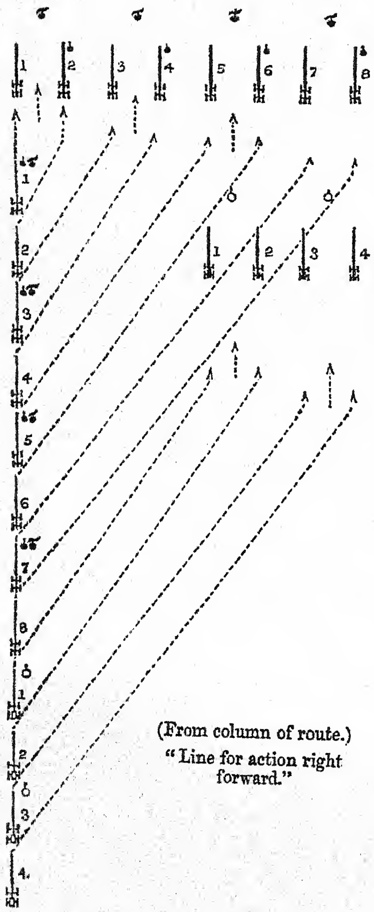


(From column of route.)
"Line for action to the front."

96. *For the formation of line to both flanks*, the command is given—

"Line (close or full intervals for action) to the front."
"Walk (trot)—march," or "March."

The first division forms up right forward, the second division moves up to the right, the third to the left of the first, the fourth to the left of the third division. The battery ammunition wagons move to their places at their relative distance in rear of the right half battery.



(From column of route.)
"Line for action right forward."

97. *To form up right (or left) of the front,* the command is given—

"Line (close or full intervals for action) right (or left) forward."
"Walk," &c.

The divisions are first formed, and move in their order to the front, towards the flank designated. The battery ammunition wagons form up like the right half battery.

98. *To form line at full intervals for action to a flank with the front reversed* (line to the right or left for action rear—Tr.), when the reversing after unlimbering does not take place, the proceeding is the same as laid down in the regulations for a division. The direction of march and the intervals are preserved as in § 8.

The battery ammunition wagons are, on receipt of the command, disengaged from the column of route, formed in line, and led at a trot into their new positions.

99. *The forming line from the reversed column* is effected in a similar manner as above. The battery ammunition wagons carry out the forming up in such manner that they may attain their relative stations. (Para. 46.)

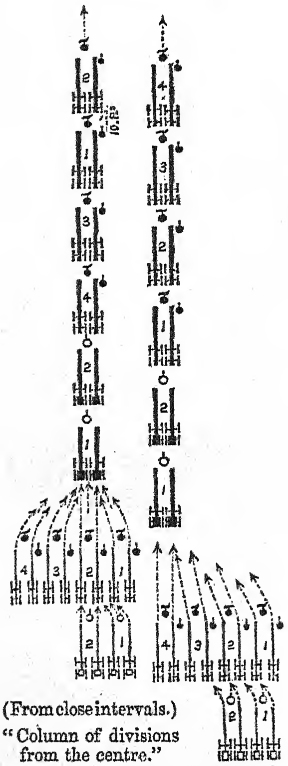
100. In other respects the instructions for the single division are observed.

§ 15.

Column of Divisions.

I.—Formation.

101. The column of divisions is employed in broken ground which allows no great breadth of formation; also in passage through other troops, and *preparatory to coming into action to a flank.*



(From close intervals.)
"Column of divisions from the centre."

(From close intervals.)
"Column of divisions from the left."

102. *To form the column of divisions on the centre,* the command is given—

"Column of divisions on the centre."
"Walk," &c.

The right centre division moves forward according to para. 77, closing its interval if necessary on the left gun. The right flank division wheels to the left, then the left centre division, and, after it, the left flank division, wheel to the right and follow in column. The battery ammunition wagons act like the right half battery.

103. *To form the column of divisions on a flank,* the command is given—

"Column of divisions from the right (left)." "Walk," &c.

The division on the flank named in the caution moves straight forward, guided as to pace by para. 77, and if necessary closes its interval towards the flank from which the movement is made. The other divisions wheel in their turn towards the same flank, close their intervals towards the same if necessary, and follow the division which has marched off, in column. The battery ammunition wagons act as in para. 102.

104. If the column is not to move on perpendicular to the old front, the leading division should be ordered to make a wheel immediately after entering on its movement. (Para. 107.)

105. *From the reversed front* the column of divisions is formed in the order of detachments indicated in paras. 86 and 87. The battery ammunition wagons, however, must at the commencement of the movement move on at the head of the column in the same direction as the divisions.

II.—Movement.

106. The commander of the division, or of the battery ammunition wagons at the head of the column, *leads* according to para. 88. The remaining detachments cover on those in front, and keep their proper distance.

107. To alter the direction in any desired angle, the commander of the battery orders—

"Head of the column—Right (left) wheel."

The detachment at the head begins the wheel, and at the word "Forward," continues its movement in the new direction.

Each of the following detachments marches forward, without having regard to their distances, and carries out the wheel at the same point as the first successively. The leading drivers must disengage their horses at the commencement of the wheel, about a carriage interval towards the wheeling flank, and only thereafter seek to cover themselves on the carriage in front of them. In other respects the prescription in § 9 is to be followed.

108. *The reversing or reforming of the column of divisions* ensues on the command—

"Battery—Reverse." "Walk (trot), march," or "March!"

By a simultaneous left about wheel of the several detachments at "Forward," the march straight forward is resumed.

109. *Exceptionally*, the column of divisions may be wheeled about to the right on the command—

"Battery—Right reverse." "Walk," &c., followed by "Forward."

110. *In order to move the column of divisions to a flank*, the battery commander gives the order—

"Battery—Flank march to the right (left)." "Walk," &c.

Whereon each detachment carries out a whole wheel to the indicated flank, and at "Forward" moves forward in the direction attained by the wheel. The commander of the division formerly at the head of the column takes up an object for direction in the prolongation of the old line of front of the detachment. The officers, &c., in charge of the remaining detachments look to their dressing and to the maintenance of their intervals.

111. *To reform the column towards the front or towards the rear*, the command is given—

"Battery—Reform to the left (right)." "Walk," &c., followed by "Forward."

Whereupon all the detachments, by simultaneous wheeling, reform the column.

112. The necessity for the flank march will but seldom occur; for in all cases where it is sought to gain ground to the flank and forwards, the movement may be carried out in the shortest way by alteration of direction of the column according to para. 107.

113. *The diminishing of distances* in the column of divisions follows on the command—

"Close to — paces." "Walk (trot), march," or "March."

In effecting this movement from the halt, the detachment at the head of the column remains stationary. The other detachments commence the movement at the pace ordered, and are made to halt by their commanders when they have attained the proper distance.

On the march at a walk, the head of the column continues at the same pace. If the pace were a trot, the head of the column falls into a walk. The detachments which follow are ordered to close up at a trot, the pace being regulated by the battery commander.

114. *The increasing of the distances* is effected by the command—

"Open out to — paces."
"First detachment—Walk (trot), march," or "March."

In effecting this from the halt, the detachment at the head of the column takes up the pace ordered. The other detachments follow at the same pace, as they attain their proper distances. On the march at a walk, the detachment at the head adopts the pace ordered, whilst the other detachments follow at the same pace, after attaining their required distances. At the trot, the detachment forming the head of the column keeps on at the same pace. The remaining detachments fall into a walk, and after attaining the proper distance again trot.

115. *The increase of intervals in the column of divisions* ensues on the command—

"Increase intervals to the right (left)." "Walk," &c.

On which, the carriages on the flank named increase their intervals to twenty paces.

116. *The closing of intervals* follows on the command—

"Close your intervals to the right (left)." "Walk," &c.

The carriages on the named flank move straight forward, the remainder close their intervals to six paces.

117. *The increase of intervals is always to be effected when under fire where the ground does not permit of the formation of the line at full intervals for action.*

118. *For transition from column of divisions to column of route*, the command is given—

"Double to the right." ("*Einzeln rechts abfallen.*")

When from the halt, the carriage on the right of the leading detachment moves straight forward at the pace ordered. The other carriage wheels at the prescribed distance behind the first. The other detachments do the same as the leading one.

On the march, the carriage on the named flank of the leading detachment continues to move forward at the original pace, or at the pace ordered. The other carriages halt and fall into the column in the manner already described, when they have attained their proper distances.

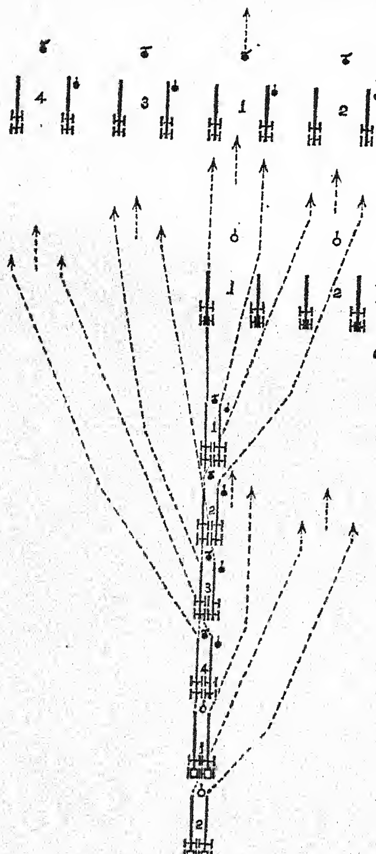
119. *For the transition from column of route to column of divisions*, the command is given—

"Divisions—Front form, right (left) forwards." "Walk," &c.

The divisions form as prescribed in exercise for the single division. Subsequently the closing of the intervals is ordered, according to para. 113.

120. On issuing from a narrow way, the column of divisions will not be formed simultaneously, but by command of the division commanders, as each issues into the open.

III.—Forming Line.



(From column of divisions.)
"Line to the front for action."

121. *To form line right and left of the front*, the command is given—

"Line (close intervals or full intervals for action) to the front." "Walk," &c.

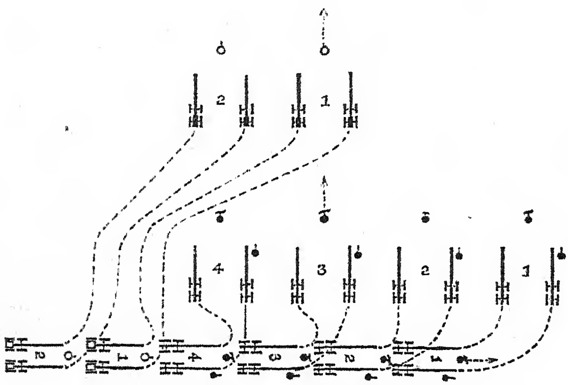
The leading detachment moves straight forward, guided by para. 78, and if required increases its interval towards the right flank. The second detachment forms up to the right, the third and fourth to the left of the leading one. In further respects paras. 94 and 95 are observed.

122. *To form line right or left of the front,* the command is given—

"Form line (close intervals, or as ordered) right (left) forward."
"Walk (trot)—march," or "March."

The leading detachment moves straight forward, and increases its interval if required towards the flank named; the other detachments are led by their commanders to their places on the flank designated.

123. *In order to form line to a flank,* the column of divisions is to be wheeled into the required line, according to para. 107, and then formed to the front.



(From column of divisions.)
"Line to the left for action rear."

124. If from column *a line is to be formed to the flank with reversed front,* the battery commander orders—

"Line full intervals to the left (right) for action rear."
"Walk (trot), march," or "March."

Whereon the divisions wheel simultaneously to the flank ordered, increasing their intervals with rapidity towards the flanks of the battery.

The battery ammunition wagons act as in para. 98.

125. *In cases of pressing necessity the guns can be ordered to halt, without regard to the intervals, after the wheel, and be unlimbered and fired.* (See para. 141.)

126. *The forming of line from a column with reversed front* is done in the same manner, and regard is had to para. 99.

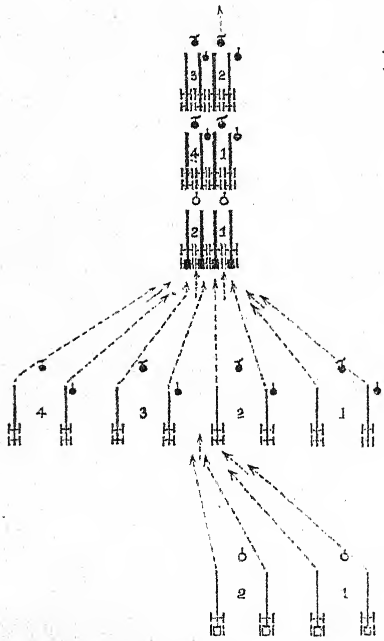
§ 16.

Column of Half Batteries.

127. The column of half batteries is the most practical formation for the manœuvres of a battery, where the ground does not permit of marching in line at full intervals for action.

128. In cautions and commands, the word "*column*" is understood to indicate solely the column of half batteries. (Para. 72.)

I.—Formation.

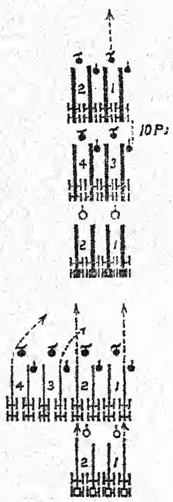


(From line full intervals.)
"Column on the centre."

129. To form *column on the centre,* the command is given—

"Column on the centre."
"Walk," &c."

The two centre divisions which have to form the head of the column, move straight to the front, and, if necessary, close their intervals on the second gun of the right centre division. The right flank division, making a half wheel to the left, follows the right centre division; the left flank division, making a half wheel to the right, follows the left centre division, and both take up their covering. The battery ammunition wagons, wheeling as much as required, take their distance and interval, following the guns.



(From close intervals.)
"Column from the right."

130. *To form the column on one flank,* the command is given—

"Column from the right (left)." "Walk," &c.

The half battery on the named flank moves straight forward, closing its intervals if necessary on that flank. The other half battery, and then the battery ammunition wagons, wheel or move up in rear of the leading detachment at their proper distance, and, in a similar manner, close their intervals.

131. If the column is to be moved off in a new direction, para. 104 is observed.

132. *From the reversed front* the column is formed in like manner. The battery ammunition wagons have to take the head of the column, according to para. 105.

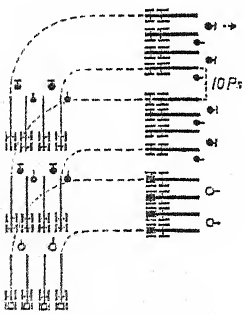
II.—Movement.

133. The commander of the right division of the leading detachment *leads* according to para. 88. The commanders of the other detachments have to dress by him.

134. *If the dressing is to be shifted to the left* (*right*), the battery commander orders—

"Left (right)—direct."

Whereon the commander of the left (or right) division of the leading detachment takes up the direction.



(From column.)
"Battery—Flank march to the right."

135. *Changes of direction, reversing and reforming, the flank march, the opening out or closing of distances, and the closing and opening of intervals, is effected as with the column of divisions.*

136. *For the transition to the column of divisions or of route,* the command is given—

"Divisions (or single carriages)—Right double." "Walk," &c.

The division (or gun) on the named flank of the leading detachment at once commences the movement, or continues it at the previous or at the prescribed pace. The remaining divisions (or carriages) act as at para. 118.

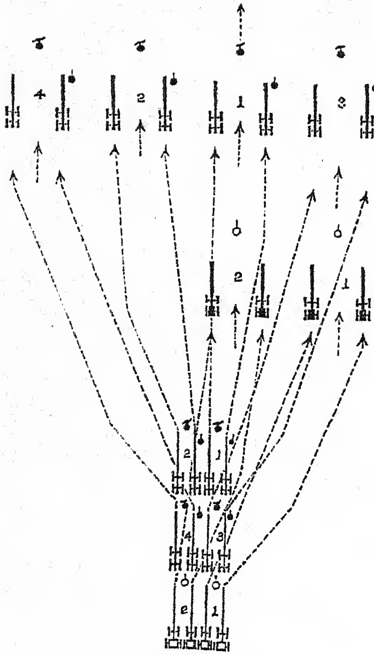
137. *The transition from the column of route or of divisions into the column* is effected by the command—

"Form column right (left), forward." "Walk," &c.

The guide for this movement is contained in paras. 93 and 119.

III.—Forming Line.

138. The forming of line from the column is effected by similar commands as with the column of divisions.



(From column.)
"Line right and left of front for action."

139. *In forming line right and left of the front,* the leading detachment marches straight forward. The right division of the rear half battery forms up to the right, the left division to the left of the front. In forming line at full intervals for action, the intervals are taken from the fourth gun of the front to be formed, and increased towards the flanks. The battery ammunition wagons place themselves in their proper relation to the right half battery, and in its rear.

140. *The forming of line right or left of the front* is effected according to para. 122; *that to a flank* according to para. 123.

141. *The forming line to a flank with front reversed for action rear* is only to be employed in cases of extreme necessity—when, for instance, the battery is suddenly attacked on its flank, or when on coming out of a defile it has to come into immediate action to a flank. The half batteries wheel rapidly towards the flank ordered, and increase their intervals towards the flanks. In other details the provisions of paras. 124 and 125 apply.

142. A column with reversed front is formed into line on similar principles. The battery ammunition wagons act as in para. 99.

Section 4.

Regulations for a Battery in Action.

§ 17.

Different kinds of Fire.

143. *The fire* of a battery is delivered in two ways—viz., as

Battery fire, in which the guns are fired at regular intervals, one after

another, from one flank, by command of the officer detailed for this duty, or as

Independent fire, in which each gun is fired as soon as it is loaded and laid, by command of its No. 1. (*Vormeister*).

In battery fire, the rapidity of the successive shots is regulated by the length of the range and the importance of the object to be gained by the fire. Every gun must be laid calmly and with the greatest care, and the effect of every shot observed. The fire is usually commenced from that flank towards which the wind is blowing.

Independent fire is employed when firing case shot, when the battery is directly attacked, or, exceptionally, when the battery has been moved up suddenly for a close attack.

§ 18.

The Opening, Carrying on, and Cessation of Fire.

144. At the time of the assembly of the battery (para. 36), the battery commander details at his discretion, one division commander to observe the effect of the shot, one division commander to conduct the battery fire and superintend the working of the guns, one for the placing and supervision of the limbers, and one for the placing and superintending the battery ammunition wagons. These duties will be taken up by the division commanders as soon as their guns are in position.

145. With a battery on the peace formation, or with a half battery, there would be told off similarly, one division commander to conduct the fire and supervise the men working the guns, and the second division commander for the placing in position of the gun limbers and battery ammunition wagons, for superintending the replacing the ammunition, and for seeing to the fighting efficiency of the battery.

In this case, the observing the effect of the shot devolves upon the battery commander.

146. *On taking up position for action* the battery commander hastens forward at an increased pace before his battery. He halts at a little distance beyond whereabouts the centre of the intended formation will be, selects the object when it is not prescribed to him, judges the distance, and decides what projectile is to be used, and what is to be the mode of fire. The battery, advancing with its centre upon the battery commander, is ordered to halt, unlimber, and (as may be required), to reverse the carriages.

147. The battery commander orders, according to the provisions of the regulations for a single division, what is to be *the range, the nature of the projectile, and the mode of firing;* he then orders, by the command

"Battery (or independent) fire,"

what the nature of fire is to be, and points out clearly the *object to be fired at;* he then betakes himself to that flank from which the fire is to begin, and conducts the trial shots for finding the range (*das Einschiessen*). *The fire is immediately thereupon opened.*

148. With the exception of fire with case shot, the first few rounds are

trial shots. They should be given in slow succession, and be watched with the greatest care, and to this end be always caused to explode somewhat in front of the object. The bettering of the elevation should at first be commenced by 100 paces at least at a time, and carried on at this rate until the object is struck, or till with the same elevation one shot is thrown in front and one beyond the object.

149. After the ascertaining the range, *the battery commander* betakes himself to where he can observe the ground in his front, can watch the progress of the action, and can under all circumstances make his dispositions in proper time.

150. *The division commander told off to watch the shot and observe their effect* places himself on the flank of one wing wherever his view is not impeded by smoke. He gives notice, by means of signs previously arranged, and which can be understood—for instance, stretching out the arm for a good shot, lifting or sinking it for every 100 paces that a shot is over or under—whether the elevation is to be adhered to or improved.

151. *The division commander conducting the fire and supervising the service of the guns* satisfies himself in the first instance that the Nos. 1 are laying on the proper object, and to this end he goes round to each of the guns. In delivering the fire every gun is addressed by its proper number. (Para. 25).

The fire is to be very slow in cases where the judgment of the distance and the observation of the effect of the shot is difficult. It is more rapid under circumstances favourable for its effect, and at distances under 2000 paces, and quickest of all when a decisive result is in immediate prospect. *All over hasty firing is to be strenuously avoided.*

152. *The division commander detailed to place and superintend the gun limbers* sees to the obtaining of the best available cover for the limbers near the guns—by getting them into hollows, behind swells of ground, by seeing the horses placed so as to be least exposed to the enemy's fire, causing the drivers to dismount, &c.—*and is responsible for the timely replenishing of the ammmunition taken from the gun limbers.* Furthermore, he must take notice of everything which bears upon the efficiency for action of the battery, and endeavour to fill up casualties in men and horses, and make good any damage to the guns. All damage affecting the fighting capacity of individual guns is to be reported to the battery commander.

153. *The division commander told off to the battery ammunition wagons* places them at a convenient distance from the battery (50 to 100 paces), having regard to the nature of the action and the conditions of the ground. They should be placed under cover in rear of the least exposed flank of the battery, and at not too close intervals. It is left to the discretion of the battery commander to order under particular circumstances that the wagons should be left still further to the rear. They should only be allowed to be placed immediately in rear of the guns in action, when they would be thereby hidden from view and well protected from the enemy's fire.

This division commander has also to direct the making good the expenditure of ammunition from the limbers. For this purpose a corporal

is always sent forward with his two ammunition wagons. One of the two begins filling up on the right flank, taking the right centre division in succession; the other wagon begins on the left flank, taking the left centre division in succession, and replace the ammunition in the gun limbers according to the regulations for instruction of the division. When the task is completed, the corporal takes the empty ammunition wagons back to the ammunition reserve at an increased pace.

Further, it is the duty of the same division commander, as soon as the wagons are in position, *rapidly to reconnoitre the ground,* and to report to the battery commander relative to its passability towards the front and towards the rear, and as to the communication with the ammunition reserve.

154. The division serjeants dismount, (according to the instruction for the division), at the command of the battery commander, see that their guns are properly placed as regards the ground, and superintend the working of the gun detachments.

155. If the horses of the division commanders attached with the guns will not stand quiet, these officers dismount, and give their horses to be held by one of their division drivers.

This rule is generally observed by all officers and N.C. officers when the battery remains long in action, and is safe against surprise.

156. *The transition from battery fire to independent firing, and vice versá, the cessation of fire and limbering up,* is ordered and carried out in accordance with the provisions for the single division.

§ 19.

Movements and Formation on coming into Action.

157. The principles laid down for the single division under this head apply in a more extended sense to the battery.

158. Rifled field guns, by reason of their accuracy and the effect of their fire, combined with their great mobility, are adapted to all the objects of field service. Consequently, their success depends entirely on a proper use being made of them. This, however, is in real warfare full of difficulties; for the efficiency of the battery depends always on the action of other troops, and on the ground; and further, the choice of projectiles and of the kind of fire to be used admits of great variety in the effect of the battery's operation. The battery commander, therefore, must understand how to adapt his measures to changes of circumstances, and to the state of the action at the moment.

159. *The commander of a battery attached by itself to other arms* is in every respect subordinate to the commander of the body of troops to which his battery is attached, and is responsible for employing his command in a proper manner. He always co-operates in the general reconnaissance of the ground, and looks out the positions for guns suited to the object in view, taking care that no obstacles exist to the advance which would impede the usefulness of the battery and occasion heavy losses.

160. As long as the battery is not actually engaged, the battery commander should remain as much as possible with the commander of the body of

troops to which it is attached, in order to acquire knowledge of the situation, of the probable designs of the enemy, and of the progress of events, and be able to receive orders personally, and, in pursuance thereof, to take his own measures for the accomplishment of the main object. During this time the battery will be led by the next senior officer, according to the instructions of the battery commander.

161. In action the battery commander will act independently, but always in the spirit of the dispositions common to the whole force, reporting at once any necessary deviations therefrom. He must know the designs of the superior commander, and learn what he decides to do. In compliance therewith, he appoints the object of fire, the nature of projectile, and mode as well as rate of firing, and regulates the replenishing of the ammunition.

162. The battery commander is not tied immediately to his command, but may quit it as much as appears necessary to enable him to reconnoitre to see how it can best be tactically employed. As a rule, however, this should only be done by him towards the front. Communications and positions in the rear should be reconnoitred by a subordinate under his orders.

163. No precise rules can be laid down for the battery commander in the manifold changes and chances of an action; *circumstances, ground, the enemy's measures and his condition, are his only guides.*

164. All *movements* and *formations of line* must be of the simplest description, and be carried out *as quickly as possible.*

165. Under all circumstances it is very important that *the battery commander should at a rapid pace precede his battery* to select the ground for its position.

166. In *broken ground* the battery commander may take forward the division serjeants with him, who pick out the best cover in the position chosen.

167. In order to hinder the enemy from seeing the strength brought against him, and to increase the effect of the fire by opening it rapidly, *the battery should advance to the attack covered as much as possible* from view, and to this end should take advantage even of rather circuitous ways of approach.

168. *In previously prepared defensive positions* the battery should only take up its ground at the moment when it is going to open fire.

169. *A position chosen for guns* should command a free view of the ground, should be favourable to the action of the fire of the battery, and, *as far as may be,* afford cover against the enemy's fire.

A moderate command over the enemy is generally more suitable than high tops of hills; because in shooting from a hill on to a plain, the space swept by fire and the explosive effect of shells is lessened, and, in case of retreat, the driving down hill consumes time and is hazardous.

The position for action should be as near as may be in a straight line; but departures from this are admissible when a better effect of fire or better cover can be obtained, and the service of the neighbouring guns is not impeded. In such cases the intervals may be made somewhat greater or less than 20 paces, as may be required.

The placing the guns between hedges, bushes, in standing corn, or in depressions of ground, tends to withdraw them from the enemy's view, and makes it difficult for him to judge the distance and to lay his guns.

170. *In the attack on unshaken infantry* the battery should be kept as far as admissible outside the effective range of musketry (800 paces), in order not to suffer great losses without being able to render essential service.

171. *In preparing an attack on enemy's cavalry* the battery should fire very rapidly at about 800 paces, until checked by the advance of its own cavalry. It then awaits the result of the attack, ready to repulse a counter attack by fire of case shot, or to evade it, under special circumstances, by a rapid withdrawal.

172. *Against artillery* the battery should avoid prominent conspicuous positions which the enemy could accurately command with his fire. It should also take up the largest allowable intervals.

Against guns of heavier calibre action should be sought at closer range, but the battery should not come within range of case shot.

173. *Hostile troops in line, especially artillery,* can best be taken from the flank. On the other hand, columns should be taken from the front.

174. *A position once chosen should be retained as long as possible,* and all changes of position of less than 300 paces should be avoided, unless there be special cause for them. The principal considerations are always these: *to be able to see the enemy, to keep him under fire within an effective range, to watch the striking of the first shots, and to better the laying in conformity thereto.*

175. The *gun limbers* should, especially in actions of long duration, be brought up into the immediate neighbourhood of the guns, and under cover (para. 150), so that at a decisive moment the guns can be limbered-up without any delay.

176. *The battery ammunition wagons* will be placed 50 to 100 paces in rear of a flank of the battery, under the best available cover. In placing them, regard is to be had to the nature of the ground, the direction of the enemy's fire, and the situation of our own troops. (Para. 153).

The forming up of battery ammunition wagons on roads is to be avoided. Where practicable they should be driven off the road to a flank, the necessary communications being established with aid of all the strength at command; in pressing cases the neighbouring troops should be called on to assist.

The battery ammunition wagons should remain in immediate communication with the battery in action, and be constantly kept informed as to the position of the ammunition reserve.

177. The battery should *resist an attack in front* as long as it can fire without danger of being captured. *It must not shrink from infantry fire, or even from the loss of guns, if the obligation of remaining in its position demands this sacrifice.*

178. If an *alteration in the direction of the fire* becomes necessary during the action, it is to be effected, according to the instruction for the single

division, by throwing the trails round, as long as this can be done without hindering the working of the adjoining guns. (Para. 157).

179. *When an increased alteration of direction is required,* the position must be changed by divisions or half batteries. The battery commander orders one of the flank divisions or one half battery, chosen according to the nature of the ground and of the action, to cease firing, and points out to its commander the new position to be taken up and the new object of fire, and gives him the order to advance or retire into the new position. This detachment must, if ordered forward, keep at a proper distance from the line of fire of the guns which continue in action, and if ordered back must keep the same condition in view. After fire has been opened by the detachment which has moved, the remainder of the battery follows successively in like manner. The battery commander accompanies the last detachment.

During this change of position the division commander will be relieved by his division serjeant in the duties devolving on him under para. 144. In the new position he resumes his previous duties.

180. *In shifting from one position to another, to front or rear, the same course of proceeding will be observed. It is a principle that the fire of the whole battery is not to be interrupted at one time.*

181. The alteration of *the direction of fire towards the rear* will be ordered and carried out as with the single division.

182. In *advancing* and *retiring, as well as in the selection of positions for guns,* the necessary regard must always be had to the other troops of the force.

183. *During the initiation of the engagement* the battery can generally choose its position with the greatest relative freedom, and with reference principally to the effect of its own fire.

In the further progress of the action it must, for the sake of security, close more upon the other troops; it must support them in their advance to the attack, by firing from positions correspondingly chosen, and, according to circumstances, if its fire would otherwise be hindered, it must accompany them even to the limit of the most effective range of infantry fire.

184. *Positions on the flanks* on somewhat advanced points have the greatest advantages, since the range thence is unobstructed, the movements of other troops are not impeded, all parts of the line are swept by fire, and the support of the line is facilitated in the case of sudden flank attacks.

185. *Formations behind other troops* with a view to firing at the enemy over their heads at a high angle, are only to be taken up exceptionally in ground of a terrace-like form, and where the position gives a command over the other troops.

186. *When a battery wishes to strengthen or relieve any detachment of guns in action,* it places itself not immediately close to them, but the guns must be driven up in front or rear, or on a flank at a convenient distance. It takes the range from the guns already in action, and thence regulates its own elevation.

187. *During retirement in action* the battery must always endeavour to get ahead of the other troops, in order to cover the retreat. To this

end, the battery ammunition wagons and the reserve wagons must first be sent back to the new position, and there be so placed that they should not interfere with the movements of the other troops.

§ 20.

Replacing Ammunition Expended.

188. *The ammunition expended from the gun limbers* will be replaced according to the instructions for the single division. *In bringing up ammunition from the ammunition wagons,* the ammunition is to be taken out of one wagon until the whole of the particular kind is exhausted. (For details, see para. 153.)

189. The division commander charged with the superintendence of the battery ammunition wagons must satisfy himself after every replenishing of ammunition, whether he cannot, by *repacking, cause one or two ammunition wagons to be entirely emptied.*

190. *The emptied battery ammunition wagons* will be exchanged at the ammunition reserve for fully packed ones, which are conducted back to the battery at a trot by the corporal in charge.

191. If the battery has changed its position whilst the exchange of wagons was being effected, the officer superintending the battery wagons must let the expected wagons know, by means of one or two gunners left behind, as to the direction the battery has taken. In case of movements in retreat, he must send his orders to meet the wagons.

192. With a half battery the ammunition expended from the gun limbers will always be replaced out of one wagon, and when it is emptied its replenishment will be effected as in para. 153.

§ 21.

Duties of the Ammunition Reserve.

193. The ammunition wagons detailed, according to para. 27, as ammunition reserve remain, at commencement of the movements of the battery, halted at the side of the road, and follow the battery at a distance of 500 or 600 paces.

194. *When the battery takes up a position for action* the ammunition reserve is to be drawn up at the above distance in such manner that it may easily be found by the empty battery wagons going to the rear. It must be safe, as far as possible, against the enemy's fire, and be able to move off towards front or rear unimpeded.

Where the cover from the ground is good, the ammunition reserve can, according to circumstances, be brought even nearer to the battery.

195. After placing the ammunition reserve in position, its commandant at once sends his orderly corporal or battery trumpeter to report its position to the officer superintending the battery ammunition wagons, and, if needful, also to the battery commander. Furthermore, some of the men, as may be required, are to be posted in the direction of the battery, in order constantly to keep up the communication.

196. *The ammunition reserve must supply all deficiencies and casualties*

occurring with the battery as quickly as possible, without regard to whether it itself remains fit to march or not.

197. *The replenishing of the wagons with the ammunition reserve* is done from the ammunition park.[1] The commander of the former informs himself by aid of his orderly corporal or battery trumpeter of the situation of the park; and to this end, if necessary, either makes enquiry from the battery commander, or, on the other hand, reports to him what he has ascertained.

198. *The emptied battery ammunition wagons* are sent back with a corporal to the ammunition park, there to make good their ammunition expended as well as their other deficiencies, and then return rapidly to the ammunition reserve. In the case of a change of position, their following after is to be provided for, according to para. 191. All material rendered unfit for service is to be brought back, as far as practicable, to the ammunition park.

199. *When the battery advances from its position* the ammunition reserve will, under all circumstances, endeavour to follow it.

200. *In movements of retreat* the battery commander must send the order to retire to the ammunition reserve in proper time. (Para. 187).

It is also the duty of the commander of the ammunition reserve, in order to avoid delays or over hurrying, to enquire of the battery commander what movements are in prospect. He uses his orderly corporal or battery trumpeter on such occasions, the necessity for which will be suggested by the state of the action.

201. It is not permissible that other ammunition wagons—as, for instance, those of the infantry—should be attached to the ammunition reserve; for the latter would by such means be hindered in its action, and might easily be drawn away from attending to its proper duty, which is, the seeing to the supply of deficiencies of all kinds in its own battery.

§ 22.

Replacing Casualties in Men and Horses.

202. *The replacing casualties among the gun detachments and drivers* is, in the first instance, to be effected according to the instruction for the single division. Beyond these limits deficiencies are to be made good from the reserve detachment with the ammunition reserve (para. 28), with all available speed.

203. *Under pressing circumstances, the battery commander should apply to the nearest detachment of other troops for the necessary reinforcement of men trained to the service of guns.*

204. *The replacing casualties among draught horses* is effected at first from the spare horses, then from a part of the horses of emptied battery ammunition wagons, and, in pressing circumstances, even from the horses

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[1] The ammunition park here spoken of is the common reserve for the artillery of the division which accompanies the division into the field, and stands in the same relation to the battery that our second line of wagons would under our existing organisation.

of the N.C. officers and officers, which must be quickly harnessed and hooked in.

205. *In respect to the moving of guns with reduced teams,* the Artillery Instruction contains the necessary information.

§ 23.

Passage of Obstacles.

206. The movements of artillery are more dependent on the ground than those of other arms. Guns and packed ammunition wagons cannot do as much in the way of getting over obstacles as individual horsemen. Although a battery which is well practised in getting over obstacles will not hesitate a moment in going at even unusual difficulties of ground, yet nevertheless such work has its limits; for in going over large ditches or drops, it is easy for damage to ensue in the shaking of the carriages, which may entail their being rendered unserviceable.

It must consequently rest with the judgment, circumspection, and experience of the battery commander to decide whether or not he should take any obstacle *when it cannot be avoided by driving round it.*

207. *The approach of an obstacle in line or column* must be effected with the greatest quiet and coolness.

208. *Ditches, with and without water, ravines, steep scarps, &c.,* are to be crossed, as far as possible, at a walk and in column, because such obstacles become less after the passage of each detachment.

209. *Marshy places* are the most to be avoided by artillery. All measures for improving the way take time. The practicable places must first be examined by single horsemen, and must be passed as may be feasible in line or in large detachments with open intervals.

210. *The battery commander* has, in principle, to deal only with the guidance of the whole. *The division commanders and the N.C. officers* must quietly precede their detachments, lead them correctly, and in case of accident, take the proper measures to help them out.

§ 24.

Escorts for Guns.

211. The artillery cannot provide for its own security against an immediate attack of the enemy.

In order to give to a battery the necessary freedom in its movements, and thereby to make it capable of coming with sudden effect into action, to protect it against the fire of skirmishers, and particularly against attacks on the flanks or rear, a proportionate escort of other troops will be permanently attached to it, which will be in every respect subordinate to the captain of the battery, and will undertake the advanced guard, &c.,[1] duties on the march, and the guard or outpost duties in camp or in action.

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[1] All these duties are expressed in German by "*Sicherheitsdienst auf Märschen im Lager und im Gefechte.*"—Tr.

212. The escort for the guns will always be chosen according to the ground and to the objects of the action. In open country cavalry is most suitable; in ground affording cover, and generally on the defensive, infantry.

213. In intersected ground which favours the enemy working his way up, and more particularly in advanced situations, the commandant of the troops will proportionately increase the strength of the escort. The battery commander should apply for this if necessary. Under pressing circumstances, however, the battery commander should claim this *reinforcement of the escort* from the nearest detachments of troops. The nearest commanders are as responsible to satisfy such a demand without refusal, as the battery commander is to make it in proper time.

214. It is the duty of the battery commander to point out to the escort given him, according to his judgment, how they can best be employed.

215. It is the duty of *the commander of the escort* to carry out the instructions of the battery commander. He is not, however, always to wait for such instructions, but will act on his own account according to the circumstances. He will engage hostile detachments approaching the battery with resolution, taking all advantage of the ground, and will seek to draw off the enemy's fire on himself, and soon to render it innocuous.

216. *In movements of the battery towards the enemy* the escort moves on the exposed flank of the battery, with a part of its strength extended as skirmishers, in order to drive back the enemy's skirmishers and to occupy the intended position beforehand. The remainder of the escort follows in close order, so as to be able to support the advanced section if needed.

217. *In retreat* the escort should remain long enough in the abandoned position to check the skirmishers who may be pressing on, and then withdraw slowly, not direct on the battery, but towards the exposed flank.

218. *In positions* the escort is never to be in rear of the battery, but always in front, and to one side of the exposed flank, and placed under cover. It should send forward skirmishers, and should actively patrol the ground, so that no enterprising hostile skirmishers or detachments should succeed in drawing near and causing disorder in the battery.

Section 5.

Movement of the Teams when not hooked in. (*Omitted.*)

Section 6.

Honours and Salutes. (*Omitted.*)

Section 7.

§ 30.

Process in Training a Battery.

249. Field artillery exhibits its entire efficiency in its fire. Its com-

manding effect at great distances, combined with the rapidity of its movements, gives it the power to open an engagement, as well on the offensive as on the defensive, at distances which lie beyond the zone of operation of infantry.

A battery detached independently may, among the manifold combinations possible with other arms, have chiefly such tasks as the following assigned to it:—To co-operate with the undertakings of an advanced guard; to initiate an engagement at long range, and keep it up; to prepare and support the attack; under some circumstances, to accompany the troops in their forward movement; to ward off counter-attacks; to check the enemy when following up an advantage, and give the action a fresh start. The battery has further to defend positions, to support attacks on villages and defiles, to cover retreats, to strengthen the rear guard, &c.

250. The battery can only, then, be equal to these manifold tasks when, well led, it is under all circumstances able to follow the other troops to where it is to be used, and where it can bring its overwhelming effect to bear in their support.

Considering the share taken by the division and other commanders in the leading and superintendence of the battery in action, and considering the difficulties in the conduct and employment of a detachment of guns in actual service, great importance must be attached to the good training of the several officers and N.C. officers. It should give them clear ideas as to the duties incumbent on them, and they should acquire the capacity to deal with all sorts of cases and conditions according to the requirements of the moment.

251. The formal prescriptions of the Exercise Regulations contain only the rules under which a battery should be formed and moved under common conditions. The appropriate selection of a regulation formation and pace under precise given circumstances can only be learnt *at exercises in combination with field manœuvres,* where regard is had to the ground and the object of the action. The division and other commanders will, profiting by these occasions, arrive at understanding the bearing of the different forms of the Exercise Regulations under various circumstances, what can be considered suitable or defective, and how far departure from them can be admissible.

Whilst a regulation execution of the special movement required must be strictly observed at drill, at manœuvres the greatest attention must be given to the variation of the ground and the object of the action at the moment, but even then the regulation form should only be so much departed from as is absolutely requisite.

In this view, these two descriptions of exercises are not to be regarded as antagonistic, but they should be held as mutually compensating, and to be connected with one another.

252. As soon as the battery is fit to execute the simplest movements in field exercises, it is to be taken out on certain days for field manœuvres. This introduces more variety in the drills, the practice is more instructive, and the battery becomes more quickly fit for service.

253. The battery commander chooses suitable ground, and gives the division commanders precisely defined suppositions.

254. The ground chosen for the instruction must be previously reconnoitred, and its selection must be carefully made, the given supposition must be adapted to it, and be withal simple, it must resemble reality, and be suited to the degree of training of the battery.

Everything in the shape of combinations for action on a large scale is to be avoided. Preference is to be shown to manœuvres on ground which is variously intersected or broken, hilly, and affording cover.

255. The division commander details the mode of carrying out the object of the manœuvre, prescribes the formations, and gives the appropriate words of command. The battery commander allows him to carry out the movement so long as the idea of it is not thoroughly faulty. He (division commander) must resolve quickly what he will do. He must have the object clearly before him, and lead his division in the prescribed manner.

256. When the division commanders are practised in handling their divisions in this manner, the battery commander selects one of their number in turn to command the battery in working out similar schemes of manœuvre.

257. Finally, the battery commander must set himself schemes to work out, in order to make himself and his battery expert, and to get it thoroughly in hand.

258. After the carrying out of every manœuvre, the whole of the officers and N.C. officers and Nos. 1 are assembled, and a conference is held concerning all that has been well or wrongly done in the measures adopted.

259. As proficiency increases, the scheme is, indeed, always to be set, but no previous explanation gone into. Practices of this description are also to be carried out on varying kinds of ground.

260. The battery commander must have these field manœuvres held in a good practical order of succession, and in their execution must see to a correct utilisation of local cover, during the march and in position; to a rapid and orderly movement to and fro of the battery; to an expert overcoming of obstacles; and to the well protected forming up of battery limbers and ammunition wagons, &c., &c.

The manœuvres should principally comprise the following:—*The selection of advantageous positions* and the forming up in them from the column of march; *the unlimbering and bringing forward of guns on roads or in defiles* to action in front of the limbers, which remain halted; *the bringing together the different divisions at a prescribed rendezvous at a given time by different roads; the advance for an accurately defined object of action* in which the other troops standing in front of the battery should be thought of, defined, and, when possible, indicated by mounted men; *the reinforcement or relief of a detachment of guns in action; the change from one position to another; the change of direction of fire* either on the same ground, or, more particularly, by change of position to a flank; *the attack and defence of localities* (Ortlichkeiten); *the advance and retreat in defiles; the unlimbering and coming into action towards a flank.*

261. In every position the guns must be laid on a given object, to which end, houses, bridges, defiles, and such like objects, and further, troops, halted or marching, are to be selected, and the distances judged.

262. It is of great advantage, when proficiency is advanced, to execute these *manœuvres with two sides.* For this, two different batteries should mutually represent each other's enemy, and the offensive or defensive attitude of each be laid down beforehand according to the ground.

263. The repeated taking up of fresh positions is not advantageous in practice of field service duties. Two or three well chosen positions aptly occupied will give sufficient material to elucidate how such operations are to be executed.

264. When the enemy is to be marked, the opening of the action can be indicated by a blank round, and the duration of the action or abandonment of a position by the setting up and lowering of a flag.

265. In order to accustom the battery and other commanders to exercise their judgment where all the conditions are on a larger scale, batteries on the full war strength are, after the half batteries (batteries on peace strength) have completed their training, to be put together by a junction of detachments, and the ammunition reserves and reserve detachments fully formed.

[End of Exercise for Single Battery.]

CHAPTER II.

Regulations for a Division of Batteries.

Section 1.

General Rules, Instructions for Formation and for Movement.

§ 31.

General Observations.

266. The following regulations contain the forms and rules for the formation and command of a division of batteries.

267. No further development should be given to these rules at drill than is necessary for the maintenance of a proper combination in the movements of the several batteries, and for the attainment of such a facility of command in the commander and aptitude of the troops as would be required of a division of batteries on real service.

268. When the batteries have acquired this aptitude on the drill field, opportunity must be given them to put into practice the formations thus learnt on varying ground. For this the necessary supposition is always to be given, as well as to the position of the

enemy as upon the attitude of our own and the strength of the enemy's forces, and finally as to the object in view. This procedure will make it clear to the troops that formation is always dependent on ground, that it is, generally, only the means to the end, and that this end is only attainable by harmony in the movements of the several batteries.

269. The movements in the division of batteries must be limited to the simplest. The most appropriate formation of a column, marches of some duration in that order, forming line, the well-timed direct advance of the line for action upon a specified object, the movement by batteries into position with the opening of a simultaneous fire, comprise the greater part of the manœuvres which a division of batteries, either when acting independently or when forming part of a larger body of artillery, can be called on to perform.

270. On actual service, the batteries of a division will not always be all together, even when moving with a common object. They will often take up positions, each for themselves, as directed by the division commandant, and also change their positions in action singly. This procedure is consequently to be often practised and regulated at manœuvres, and in the offensive as well as in the defensive.

§ 32.

Tactical Composition of a Division of Batteries.

271. A division of batteries consists of two, three, or four batteries, which are united under a common command.

§ 33.

Formations of a Division of Batteries.

272. The following are the formations in which a division of batteries can be moved:—

1. In line at full intervals for action.
2. In line of columns.
3. In mass (so called.—Tr.)
4. In line at close intervals.
5. In column.
6. In column of divisions.
7. In column of route.

I.—Line at Full Intervals for Action.

(Called "fire line," *lit.*)

273. In the line at full intervals the batteries are placed in one line, with intervals of 30 paces.

274. This interval is called *battery interval.* In manœuvring it may be increased, according to the ground and the nature of the action. In formations of line, attention need not be so much paid to the scrupulous preservation of the battery intervals as to the maintenance of the proper order within the batteries themselves.

275. *The batteries are always to be named* according to the places they occupy in the division.

They will be named in the following manner, from right to left:—

Right flank }
Centre } Battery.
Left flank }

Where there are four batteries, that on the right of the centre is called the "right centre battery," that on the left of the centre the "left centre battery."

When the front is reversed, batteries and flanks retain their previous telling off.

276. *The line at full intervals for action* will be adopted when in position, and for the direct advance or retirement within the enemy's effective range, when the ground admits of it.

II.—Line of Columns.

277. In line of columns, the batteries, each formed in column, stand with their fronts on the same alignment, preserving the necessary interval for forming line of 150 paces.

278. In a division of batteries formed of batteries on a peace strength, the individual batteries will be formed in the line at close intervals (para. 30), and preserve intervals of 70 paces.

279. The line of columns, together with the highest capacity for manœuvre, admits of the most rapid formation of line, and is a good formation to adopt preparatory to the development of the line for action.

280. If needed, the intervals and distances in the individual columns can be increased, according to paras. 114 and 115.

281. The telling off of the batteries is the same as in the line for action. (Para. 275.)

III.—Mass.

282. *In mass* the batteries stand beside one another as in the line of columns, but with battery intervals of 10 paces.

283. The batteries will be told off as in para. 275.

284. The formation in mass is generally made use of when the batteries are to be drawn up without the enemy's range of fire.

IV.—Line at Close Intervals.

285. *In line at close intervals*, the batteries, each formed in line at close intervals, are drawn up side by side with battery intervals of 10 paces.

286. The telling off is the same as in para. 275.

287. The line at close intervals is used when the available space does not admit of the formation in mass.

V.—Column.

288. In the *column*, the batteries, formed each in column, according to § 16, stand one behind the other at distances of 30 paces (called "battery distance.")

In manœuvring, a scrupulous preservation of battery distances is not to be sought after, but rather that the individual batteries should be well closed up, each for themselves, and that they should correct their distances when necessary by the gradual adoption of the proper pace.

289. *The increase or lessening of battery distances*, as also of those of the fractions within each battery, is effected as in § 16, regard being always had to the correct battery distance. (Para. 288.)

290. The individual batteries will be named, according to their position in the column, in the following manner, counting from the head to the rear of the column :—

Leading
Centre
(where there are four batteries)
Rear centre (*lit.*, "last but one.")
Rear (*lit.*, "last.")
} Battery.

If the column is reversed, the batteries are named as above in the same manner from front to rear.

291. The formation in column facilitates the formation to either flank, and in any required direction. Nevertheless, it is only to be employed in manœuvring when the ground and circumstances do not admit of any other formation.

292. Should the division find itself when in column within the enemy's range of fire, which would only occur exceptionally, the provisions of para. 117 are, where practicable, to be carried out.

VI.—Column of Divisions.

293. The single batteries are formed in columns of divisions.

294. In other respects the same instructions are to be followed as given for the column.

295. The column of divisions is employed in flank movements, also in transition to the formation of the "column," and lastly where the space is confined.

VII.—Column of Route.

296. The batteries formed in column of route follow one another at battery distances.

297. The column of route is only adapted for marching, or for getting through narrow ways, but not at all as a formation for manœuvre. For the latter purpose, whenever the ground admits, the preparation for coming into action is always to be effected by previously forming divisions or half batteries, partially if not entirely.

298. The rules given regarding the "column" are applicable also to this formation.

§ 34.

Formation of a Division of Batteries.

299. The batteries of a division will be formed side by side, or in rear of one another, according to the dispositions of the commander of the division, in some one of the formations described in § 33.

300. The commanders of batteries report the number of guns turned out to the division commander, according to the rules prescribed for the reception of a superior officer (§ 27), and then betake themselves to their places.

301, 302, and 303. * * * * *

304. In order to accustom the eye of the division commanders, and also of the commanders of batteries, to operations on a larger scale, and also to enable them to see the actual difference between the handling of a division of batteries on the peace strength and that of one on the war strength, the practice should be observed, after the individual training has been fully attended to, of forming a division of batteries, by bringing together several batteries on the war strength.

§ 35.

Detaching the Ammunition Reserve.

305. The ammunition reserve of a division of batteries is formed by bringing together the ammunition reserves of the several batteries. These will be formed up, accordingly as the ground admits, in line at close intervals or in column of divisions, side by side, or one in rear of the other. The intervals or distances between the several battery ammunition reserves is to be 10 paces.

306. *The command over the ammunition reserve* of a division of batteries is to be held by an officer, to be named by the commandant of the division.

307. *The ammunition reserve is to be kept as much as possible out of the enemy's range of fire.*

308. Its place of formation, and the alterations in its position in moving to the front or rear, are to be determined by the commandant of the division, and must each time be made known to the commanders of batteries.

When the division moves forward or retires, the necessary intimation of the movement is always to be sent to the ammunition reserve betimes, so that delays or over hurrying in its movement may be avoided.

Should, exceptionally, the command for shifting position not reach the commander of the ammunition reserve, he should ask for instructions from the division commandant; under pressing circumstances, he should act without delay on his own responsibility, reporting the steps taken as quickly as possible.

309. When a battery is detached, its ammunition reserve follows it without delay.

310. In other respects the rules given for the ammunition reserves with single batteries are to be followed.

§ 36.

Nomination of a Battery of Direction.

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§ 37.

Rules for Commands and Soundings.

315. The division commandant directs the movements either by the voice, with the necessary soundings, or sends his orders to the several batteries by orderly N.C. officers.

316. Each battery, and also the division ammunition reserve, should at the commencement of the manœuvres, and without being told, send an orderly corporal (para. 31) to join the division commandant. These N.C. officers keep in rear of the division commandant, and accompany him always, unless he sends them elsewhere.

317. Every order of the division commandant consists of three parts, viz.:—

1. The command or sound, "Attention."
2. The caution; such as the simple naming of the formation to be assumed, and, when necessary, also the pace.
3. The sound for "Execution" (of the order).

The command "Attention" is only to be repeated by battery commanders exceptionally, when it is absolutely necessary.

On receipt of the *caution*, each battery commander either communicates to his battery, by command or sword signal, the order for the corresponding preparatory movement, or, as the case may be, simply repeats the caution given.

The sound for "Execution" is not to be repeated, but each battery commander gives the word of command or the sword signal to his battery at the right moment when it has to commence its movement.

318. When the command given by the division commandant is one which has to be carried out by all the batteries simultaneously, the *caution* is in such case always to be preceded by the word "Division."

319. In the regulations here following, the *caution* only is given, the calls to "Attention," the pace, "Execution," and "Division," which should precede or follow the caution, are omitted.

320. In communicating certain cautions, the division commandant can

avail himself of the following, in addition to the soundings prescribed for the single battery :—

1. "Line for action;" which serves as a caution for the formation of line.
2. "Forward," "Back," or "To rear," "Right," "Left," as pointing out the direction in which the movement is to be made.

The simultaneous moving off of the batteries in the formation in which they are standing, is ordered by—

"Attention," followed by
"Walk," (trot), and then
"Execution."

The cessation of movement by "Attention" and "Halt."

321. If an order affects one battery only, the division commandant addresses it as "— battery," according to paras. 275 or 290.

322. The greatest caution is especially to be used in employment of soundings in enclosed broken country, and near other troops, as misunderstandings could easily arise which could not be repaired.

323. In such cases, and particularly in action, the division commandant should give his orders *verbally*, by dispositions which can either be communicated personally to the battery commanders concerned, or be sent through the orderly corporals, or in important cases through the adjutant.

324. The adjutant or orderly N.C. officer, before riding off, must repeat literally the order to be conveyed, and as soon as he has delivered it must return rapidly, without delaying, and again repeat, for the sake of certainty, the order he has given, and report whatever answer or information he has received.

325. Every order is, as soon as it is understood, to be carried out without hesitation, except when it is at the same time ordered that a sound for the execution, or the arrival of precisely defined circumstances are to be awaited.

If the order was obscure, it is the duty of the battery commander at once to send for it afresh.

326. This method of conveying orders is the nearest to what actually takes place on service; it is therefore to be practised at exercise, and is to be always adopted as a rule at manœuvres.

The orders must be concise, definite, and based on the terms used in the regulations, and must show in a brief form what the division commandant intends.

327. As the battery commander has often, in execution of such orders, to consider the state of the action, and not seldom the proper object of the instruction received, and the time for carrying it out, a proper latitude should always be allowed him in this regard.

§ 38.

Duties of the Commandant.

328. The commandant of the division should place himself to give his

orders in such a position, at a proper distance from his command, that he can be understood by the commanders of batteries, and can also supervise the execution of the commands he gives.

If the division commandant stops too close to his batteries, both his supervision and power of command are impeded.

329. In every case of the division commandant removing himself far from his command, the senior battery commander takes up the command of the division. The same thing takes place whenever two or more batteries of different divisions are brought together for a common object.

330. At manœuvres, the division commandant should look to the essentials only, and to what conduces to the true object in view; he should not occupy himself with details, but should see that the battery commanders comprehend his orders aright, and carry them out in the simplest and most appropriate manner.

331. *The battery commanders, on the receipt of every order of the division commandant, have rapidly to picture to themselves the conditions of the new formation; they have then to lead their batteries into their appointed places independently and on the shortest lines, without, however, losing sight of the nature of the ground and of the requirements of the action.*

332. *In conducting their batteries into a defined alignment* the battery commanders have to place themselves so that their batteries should come up between them and the *point d'appui* of the formation. In this way they can see that their batteries come up properly into the line of dressing, and can order the halt at the right moment.

333. In the formation or in movement of a deployed line of batteries, the commanders of the flank batteries may place themselves towards the inward flank of their batteries near the commandant of the division, in order the better to understand his orders.

334. *The commandant of the ammunition reserve* behaves in general in accordance with the provisions of § 35. Further directions are given in § 53.

§ 39.

Use of the Paces.

335. * * * * * *

336. The commandant of a field battery division, when he orders a movement at a rapid pace, should wait when necessary long enough, before giving the signal for execution, to enable the battery commanders to cause their men to mount.

337. *All changes of formation* and *deployments* must be effected by the several batteries at a trot.

338. The *rule* is that that battery which has the shortest way to go in reaching its appointed place, begins the movement, when it is made from the halt, at a *walk*, and when it is made on the move, it drops into a walk, or continues moving at that pace.

The other batteries commence the movement *at the pace ordered*, or continue to move at a trot, as the case may be, till they get into their proper places in the division, whereupon they drop into a walk.

339. [1] Exceptionally, when the division commandant finds it expedient to do so, he should, after the battery which has the shortest way to go to get into its place has taken up the new direction and has completed the new formation, order that battery to halt. The other batteries then also halt when they have got into the new formation.

§ 40.

Dressing.

340. *The line of dressing of a division of batteries* is determined according to para. 38, and both for the deployed line as well as for the line of columns or the mass, it is effected on the battery of direction.

* * * * * *

Section 2.

Movements of the Deployed Line, of the Line of Columns, and of the Mass. Changes of Formation.

§ 41.

March to the Front.

344. The march of a division of batteries to the front in one of the above-mentioned formations, is the simplest movement for gaining ground to the front.

345. The choice of one or other of the forms depends on the ground and circumstances of the action.

346. Immediately under fire, the march to the front should be effected in line at full intervals; in difficult ground, in line of columns. The mass is only to be employed out of the reach of fire, and for short distances.

347. *The march to the front at full intervals* is always the most difficult but the most important movement of the artillery. In decisive moments, the successful result of the advance of a division of batteries into action depends upon the rapidity and regularity with which this movement is executed. The march to the front at full intervals is therefore to be practised with great care at all paces, and much attention is to be given to the direct movement of the several guns upon the object, and the avoidance of all swerving from side to side when under the enemy's fire.

348 * * * * * *

349. Before the movement commences, the division commandant names a point of direction, and points it out to the commander of the battery of direction, and, with long lines, also to the other battery commanders.

351. Before commencement of the march, the commanders of batteries name the flank nearest the battery of direction as the directing flank, if this has not been already previously ordered.

During the movement they watch the officers, &c., charged with

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[1] The provisions of 338 and 339 are the same as for the cavalry under similar circumstances.—Tr.

the leading, and point out to them, if necessary, to which flank they have to incline. Such inclining is, however, only to be taken up gradually.

352. *The movement must always begin quietly, and all the more so the longer the line is.*

The battery of direction must keep up a very uniform pace, and avoid all swerving. The other batteries must never get in front of the line of dressing of the battery of direction. The flanks, if anything, should remain rather in rear of the line.

353. If the division commandant gives the command or sound to stop the movement, the commanders of batteries have to order their batteries to halt. In doing this, it is left to their discretion to give the command or sword signal rather later, so as to allow faults in dressing to be corrected.

§ 42.

March to the Flank.

* * * * * *

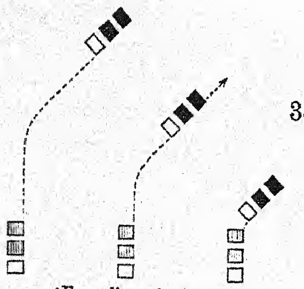
§ 43.

March to the Rear.

* * * * * *

§ 44.

Change of Front.



(From line of columns.)
"Change of front to the right."

357. In the division of batteries, "changes of front" take the place of "wheels," and are only admissible when the object is to advance one flank (at the utmost to an angle of 45°).

358. * * * * * *

359. When *a change of front is to be made in line at full intervals*, it must be left to the consideration of the commanders of batteries whether they (with the exception of the pivot battery) carry out the change of front with their batteries in line, or whether they should form them into column, and move them into the line of dressing in that order.

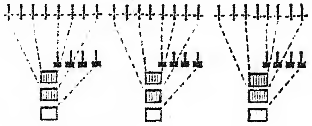
360. *A change of front through an angle of* 90°, which would only be carried out at exercise in a confined space, is to be effected by means of two changes of front to right or left, but it is never to be executed in line at full intervals.

§ 45.

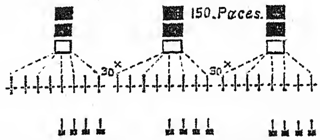
Changes of Formation.

361. For the formation of line for action at full intervals from line of columns, the command or sound is given—"Line for action."

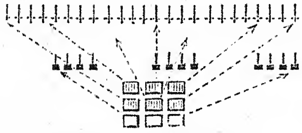
362 to 367. (Similar directions.)



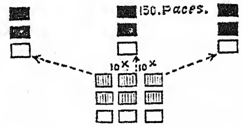
"Line for action."



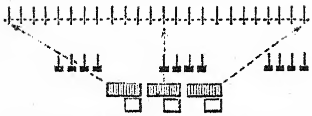
"Line of columns."



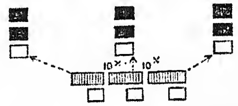
"Line on centre battery."



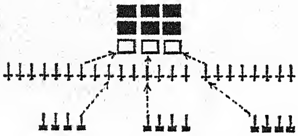
"Line of columns on centre battery."



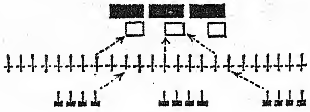
"Line for action on centre battery."



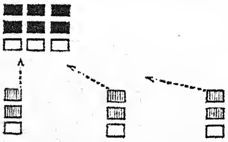
"Line of columns on centre battery."



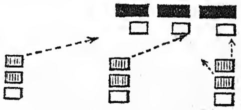
"Mass on centre battery."



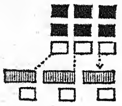
"Line close intervals on centre battery."



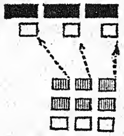
"Mass on left flank battery."



"Line close intervals on right flank battery."



"Mass on right flank battery."



"Line close intervals on right flank battery."

Section 3.

Formation, Movement, and Deployment of Columns.

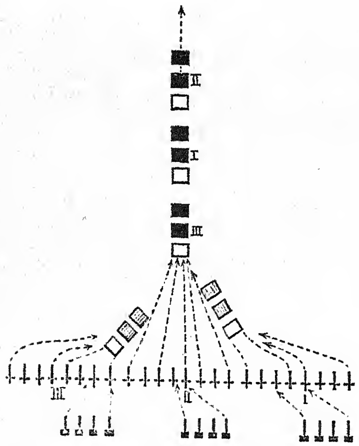
§ 46.

368. * * * * * * As a rule, all columns are formed from the halt.

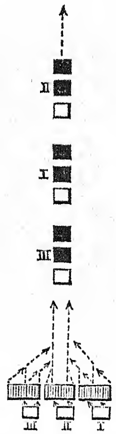
369. *To form column from the halt towards the front* from any other formation, the command is given—

"Column (column of divisions or of route) on the — battery."

The named battery moves straight forward at the pace ordered, at the same time changing its formation if necessary, having regard always to the previous formation—that is, forming column right forward, or left forward, or on the centre, accordingly as the battery



(From line full intervals.)



(From line close intervals.)

"Column on centre battery."

stood on the left or right flank, or in the centre of the division.

* * * * * *

370. It is a principle that in the formation of column on a centre battery, the latter is followed first by those batteries which were on its right, then by those which were on its left. In marching off from a flank, the batteries take their places in column in the order in which they stand.

371. For the formation of column from a halt towards a flank, the command is given—

"Column (division or of route) to the right (or left)."

372, 373. * * * * * *

§ 47.

Movement.

374, 375. * * * * * *

376. The division commandant rides at a suitable distance on the flank of the column. The battery commanders betake themselves to the same flank as that on which the division commandant is.

* * * * * *

§ 48.

Deployment.

384. Line can be formed from column either towards the same front as that held by the column, or towards one of the flanks. In the former case, the line is formed up either to both right and left of the head of the column, or, if need be, only to one side. Deployment should always be effected during movement.

385. Deployment to *right and left of the head of the column* is the quickest. It is to be employed as a rule. The formation to *one side of the head of the column* is only to be adopted when necessary—as, for instance, when there is a deficiency of space.

386. The deployment of the column should be effected, when practicable, without the range of fire, behind cover, in dips of ground, &c. When circumstances permit it, preparation should be made for a rapid deployment by a previous formation of the line of columns.

387. After every formation of line, the further march to the front should proceed in the direction given by the division commandant, and without any check.

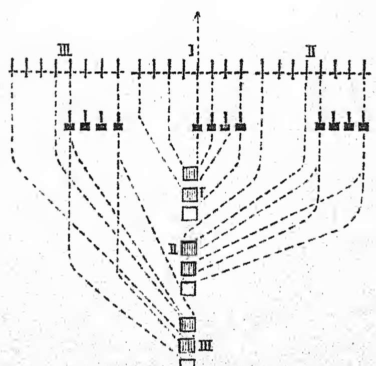
388. To this end, the division commandant should place himself to give the command for forming line always at that point towards which the centre of the line to be formed should move. He should not lose sight of the provisions of para. 349—viz., to give the point of direction to the battery of direction, making it known also, when the line is long, to the other battery commanders.

390. *To deploy to both sides of the head of the column*, the command is given—

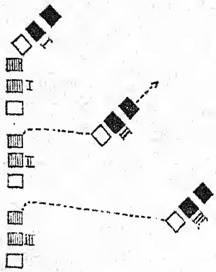
"Line for action (line of columns, line at close intervals, or mass) to the front."

*   *   *   *   *   *

The changes of formation necessary are effected during the movement.



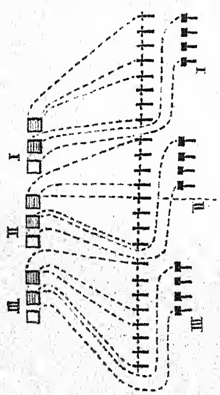
(From column.)
"Line to the front for action."



(From column.)
" Head of the col.—Right wheel."
" Line of columns to the right of the front."

392. If the division commandant intends to deploy the column *in an inclined direction or towards one of the flanks,* he directs the head of the column to make the amount of wheel required, and immediately afterwards orders the formation of line.

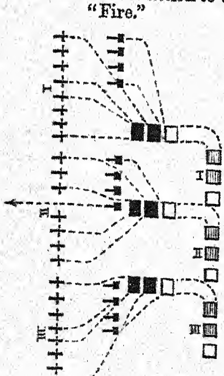
393. If the division commandant wishes *to open fire immediately whilst the deployment is in progress,* he gives the sound "Fire." Whereupon the battery at the head of the column halts, and at once opens fire. The other batteries also open fire successively as they arrive in line with the leading battery.



(From column.)
Sound: "Line for action to the right."
"Fire."

394. *To open fire towards a flank from the reversed front,* the following sounds only are given—
"Line for action." "To the right." "Fire."

* * * * (See para. 141.)



(From column.)
(Through orders transmitted.)
"Batteries left wheel."
" Line for action on centre battery."

396. The division commandant can, besides, direct the formation of line in every direction and from any formation, by sending his orders to the several batteries. In every such case, however, the new direction of march must be given to all the batteries. (See para. 349.)

Section 4.

The Division of Batteries in Action.

§ 49.

Regulation of Fire.

*   *   *   *   *   (See § 17.)

§ 50.

Opening, Conducting, and Cessation of Fire.

399. The division commandant should precede his division at a proper distance in advancing into action, and should place himself nearly in the centre of the position chosen. The battery commanders accompany him only when specially ordered. When time admits, the orderly corporals are sent to the points on the centres of which their respective batteries will rest approximately.

The division in the meantime follows, commanded by the senior captain under the directions of the division commandant.

400. The division commandant gives the sound for the opening of fire by batteries—"Fire," sounded once, or, for independent firing, "Fire," sounded twice. The commandant then moves to the point where he considers his presence most necessary.

401. The battery commanders order their batteries to halt, unlimber, and place their guns as required. They then direct the opening of the fire, and act in other respects according to paras. 147 to 149.

402. *   *   *   *   *   *

403. Fire should be opened as unexpectedly as possible. It should therefore commence as simultaneously as may be, and be conducted by all the batteries *against one and the same object, which is to be indicated by the division commandant.*

404. A division of batteries *should only open its fire at distances* at which good results can be expected—as a rule, not over 2000 paces. Large bodies of troops in motion, masses of cavalry, reserves, &c., can be fired upon up to 2500 paces.

405. In the action introductory to an engagement, or in that having for its object to *contain* the enemy, *fire* should be delivered very slowly, and in the latter case one battery can be made to relieve another in firing, in order to arrive at a more uniform expenditure of ammunition. As the development of the action proceeds, and the decisive moment approaches, fire may be more active. At the decisive moment itself, the infantry or cavalry masses should be fired upon rapidly, but always without any hurry.

406. *The joint fire of all the batteries is always to be directed on the body of troops which assumes the most threatening attitude at the moment.*

As a rule, infantry or cavalry should be fired upon as soon as they come within effective range; artillery, on the other hand, only when our troops are suffering sensible losses by their fire. The

object of fire will also often be accidents of ground, or cover favouring the enemy's defence, or from which he has to be driven.

407. *The cessation of fire* is ordered by the sound "Cease firing," which is taken up and carried out in the batteries by the several commanders.

408. If the division commander contemplates an advance, he gives, after the cease fire, the sound "Forward," or, for retreat, the sound "Back," or "To rear;" whereupon the battery commanders give in the first case the command to limber up to the front, and in the latter case to the rear.

§ 51.

Movement and Formation for Action.

* * * * * *

II.—Duties of the Commandant.

414. The commandant of the artillery of a division observes in general the prescriptions of § 19.

415. Being attached to the commander of the army division as a coadjutor (*Hilfs-organ*), he makes the necessary proposals for the distribution, movement, and employment of the artillery of the division, in the order of march and order of battle, and, on their adoption, he issues directly the orders for their execution.

416. The movement and placing of the *division ammunition park* is similarly ordered by the commandant of the divisional artillery. *The situation of the division ammunition park is always to be made known to the commanders of batteries and the commander of the ammunition reserve.*

417. The commandant of the divisional artillery is responsible for the proper employment of the batteries under him. He must supervise the taking up of positions by them, correcting them if necessary.

418. Where more than two batteries are to come into action together, or the working of the artillery "*en masse*" is contemplated, the division commandant should himself undertake the conduct of the fire.

419. If it is necessary to attach guns to positions of the army division for special services—as, for instance, advanced and rear guards, flanking movements, &c.—whole batteries should as far as possible be detailed, and the dissemination of guns in divisions or half batteries be avoided.

420. The portion of artillery which is detached returns again, when the detachment of troops to which it was assigned has completed its task or has rejoined the main body, to the divisional artillery.

421. The commandant of the divisional artillery should take part in the general reconnaissance of the enemy's position, and of the ground on the hither side of it. He should remain with the commandant of the army division as long as his batteries are not in action. He should, under all circumstances, be aware of the dispositions which have been made, and should learn the alterations introduced

as they occur, in order to be able to make the most suitable dispositions for his batteries in accordance with them.

422. Battery commanders should be present at the reconnaissances or not, as circumstances may dictate. In every case, however, the general dispositions and the object of the action should be made known to them, and in proper time, so that they may be in a position to carry out their instructions in view of that object.

III.—Employment of Batteries according to their Calibre.

423. *In the choice of batteries* for the different objects which occur on service, attention should be paid, where circumstances permit, to their mobility as well as the efficacy of their action.

Précis.—8-prs., by reason of their range and power, are suitable for dismounting enemy's artillery, shaking the masses of his troops, for the attack of villages, destruction of buildings, shelling of troops (with reduced charges) behind entrenchments or under cover. Thus they would generally accompany the main body, being only exceptionally attached to the advanced guard when villages or defiles are to be attacked, &c. They should be employed with the rear guard when ground is to be occupied where a long range can be commanded.

The 4-prs. are less efficacious than the 8-prs., but are lighter and carry more ammunition, and are thus more independent of the ammunition columns. In addition to being capable of employment for similar purposes as the 8-prs., they are more suitable for detachment, for artillery actions at distant points of the field, with the advance or rear guard, for turning movements or flank attacks, and for reinforcing the fire of other batteries.

Cavalry batteries are suited for rapid movements over a considerable distance of ground, even in difficult country, especially also as an aid to the cavalry to protect their deployments, and in attack to increase their independence, and on occasion their power of resistance. They are further suited for the rapid support of threatened points of the line of battle, and for sudden attacks on the enemy's flanks.

IV.—Order of March.

427. The arrangement of batteries in the order of march of the army division is determined by the object of the action in view. The following points should, however, always be borne in mind:—That the artillery should be capable of being moved up in as united a body as possible in proper time for initiatory action in an engagement, for its prosecution, or for its decision. To this end, the artillery should march not far from the head of the column. On the other hand, for the sake of its own safety, it should not be too near the enemy.

428. *In the offensive* a 4-pr. battery will generally be attached to the advanced guard. Under particular circumstances, however—especially when the advanced guard is to be dependent on itself for

a protracted time—two batteries, or even the whole divisional artillery, may be attached to the advanced brigade. The other batteries will be ranged all in one column behind the head of the main body.

429. *In marches to the rear and retreats* the arrangement of the batteries in the general order of march is determined by the vicinity of the enemy, his intentions, the ground, and other circumstances—for instance, whether the artillery should go on to take up a defensive position in which to receive the retiring troops, or whether they should remain in the old position.

430. *In flank marches* in the neighbourhood of the enemy, no special rules can be given as to the place of the artillery. Circumstances can alone determine this in each case—as, for instance, whether the enemy is to be attacked with a portion of the troops whilst the remainder prosecute their flank march under their cover, &c., &c.

V.—Taking Position.

* * * * * *

434. The placing of the battery ammunition wagons of a division of batteries is more difficult than in the case of a single battery. It will not always be possible to avoid placing them in rear of their batteries, and therefore in a rather dangerous position. It will, however, be sometimes practicable to place the wagons of several batteries together, beside or behind one another, on a favourable site.

VI.—Behaviour in the Offensive.

435. At the commencement of an offensive action the divisional artillery has to cover the battle formation of the army division by taking up an appropriate position. Its movements at this time being in no way cramped by the other troops, it can select the most favourable ground for its position without reference to them.

436. The force of artillery to be brought into action during the introduction to and development of the engagement, is determined by the resistance offered by the enemy and by the object in view—viz., whether he is merely to be occupied or seriously attacked.

As a rule, the action should at the commencement merely have a "*holding*" (*or* "*containing*") *character—i.e.*, so that with the least possible expenditure of strength or ammunition on our side the enemy should be occupied, and betrayed into waste of both.

For precaution, a portion of the batteries should be kept in hand for unexpected occurrences, or for use at the decisive moment. Success will be all the more assured the less the strength which is developed in the earlier stages, and the greater the number of guns which remain over, with which to meet the enemy at the right time and place with a superior fire.

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439. The most effective position for artillery is on the flanks. The batteries can there remain in action longest without hindering the movements of the other troops, and thereby most effectively draw the enemy's fire off the troops on to themselves. Positions on both flanks cover the front best. Under particular circumstances, also, the divisional artillery, or a part of it, can be placed in front of the line; and to this end, the ground in front of the larger gaps in the line should be chosen.

If, however, the point is to decide the action by a superior development of artillery fire, then the whole divisional artillery should be united in one suitable position.

440. In order that any artillery on the flanks should be able to act continuously without being disturbed, it should be protected against immediate attacks on its flank, either by having an *appui* on impassable ground, or by being covered by our own troops.

441. If the artillery can continue its fire on the enemy from its original positions uninterruptedly during the advance of the other troops to the attack, it is of great advantage. * * * * * Where this is not practicable, a portion of the batteries, or in pressing circumstances even the whole divisional artillery, must follow the advancing troops, in order to break by their fire the opposition of the enemy's infantry. Such advance should be effected successively by batteries, so that the fire should never be altogether discontinued. * * * * * * * * * * * *

442. The artillery awaits the result of the attack with guns in action. If it is unfavourable, it checks the pursuit by the enemy through its fire. The batteries are never to retire at such a moment, and must wait firmly, even under musketry fire, if the repulsed troops are to be reassembled under their cover, and the attack by the second line is to be supported.

At such moments the artillery should look out for cavalry attacks on the flanks of the infantry, and defeat them by their fire.

443. If the attack succeeds, a portion of the divisional artillery should hasten forwards to join the infantry, which at this moment is generally left to its own support. The other batteries keep up, in the meantime, a lively searching fire on the enemy's reserves from their advanced positions on the flanks, with a view of hindering their being brought up. They will only be advanced to the front when the infantry has established itself in the new position.

444. With a view to the above, the artillery should seek to choose their last positions, before the infantry attack is delivered, in such manner that they may be able to command the interior of the enemy's position as long and to as great a depth as possible.

VII.—Behaviour in the Defensive.

445. On the defensive, fighting by fire is more particularly resorted to. The principal *rôle*, therefore, generally falls to the artillery.

In such cases the other arms should always regulate their position by that of the artillery.

446. * * * * * * Under every circumstance, a reserve, however small, should be kept in hand. 4-pr. batteries are the best adapted for this.

447. * * * * * * The best positions are those which are well advanced, whence the enemy can be well searched and taken in flank during his advance. For the occupation of these, 8-pr. batteries should be selected, all subdivision of batteries should be avoided, and they should be protected against immediate attack by other arms.

448. * * * * * *

449. The batteries should be kept, as far as possible, hidden before the action commences, and be only brought into position when the fight begins, advantage being taken of the ground in every way in so doing.

450. On the defensive, the fire of the artillery should, as a rule, be directed and concentrated on the enemy's attacking troops. Artillery should only exceptionally undertake a duel against artillery, and indeed only when the object in view is to draw off the enemy's fire from our troops on to the guns.[1] Firing on the enemy's guns leads commonly to no issue; batteries should generally fire on the infantry. The columns which are pushing on the most eagerly make always the most appropriate targets.

451. If the enemy's artillery has got its range, and attains a superiority, the batteries should shift their positions from time to time, if the state of the action in any way permits, in order to throw obstacles in the way of the enemy's judgment of the distance and laying his guns.

452. If the enemy's infantry advances to attack, the whole of the artillery in reserve must be brought up into line towards the threatened point. It must remain to the last in the position taken up, and in case of pressing need even sacrifice its guns.

453. If a retreat is ordered, the divisional artillery does not enter on it all at once, but, where practicable, by batteries. Rallying positions (*Aufnahmstellungen*) on the flanks of the line of retreat must be quickly taken up.

Self-sacrifice must be shown in protecting the retirement of the other arms, and in facilitating their reforming.

Whilst a portion of the divisional artillery goes back quickly to take up rallying positions, the remainder keep with the troops,

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[1] Is the most advantage taken in modern tactics of the liberty of movement and of formation allowed to the artillery? In all cases where artillery is exposed to the fire of artillery it would seem very advisable to increase, where the ground admits, the intervals between guns much beyond that which is usual. Would not a battery of guns on the usual front find an uncommonly formidable assailant in a battery formed at double intervals, or intervals of 30 yds.? Its fire would have to be directed on individual guns; shells bursting in the intervals would be ineffective. It would seem that unusual care and accuracy would be necessary to make the fire effective under these circumstances.—Tr.

so as to support them at any moment in making head against the enemy.

The fire of the guns which hold the rear should be directed principally on the enemy's pursuing infantry and cavalry; and in the case of attacks at close quarters, the defence should be maintained with case shot up to the shortest possible ranges.

454. The order in which the batteries should retire is determined by the progress of the action, and will be ordered by the commandant of divisional artillery. It depends on the views of the superior commander to decide whether the batteries should hold on in the positions, even to the sacrifice of their guns. *As a rule, no detachment of guns should quit its position in action without orders from a superior.*

455. In the case of attacks by cavalry, a resolute maintenance of its position by the artillery, and a rapid, cool delivery of fire of case shot, has generally the best results. On the other hand, a hurried quitting of the position, in order at the last moment to seek refuge among the infantry, generally only leads to confusion.

VIII.—Change of Direction of Fire.

456, 457. * * * * * *

458. In every such case (of partial change of direction of fire), a division of batteries should never let itself be led away to a scattering of its effect by immaterial secondary considerations. The principle of the united harmonious action of the whole divisional artillery towards one and the same object should always be upheld.

IX.—Changes of Position.

459. *Batteries must, in order to fire with effect, remain as long as possible in their positions.* They should only leave those positions when the object of action is either attained or is no longer attainable, or when a longer continuance in them only brings danger without contributing to the decision of the action.

460. The distances between the positions of a division of batteries in advancing or retiring should, as a rule, not be less than 500 paces.

461. The advance or retreat of a division of batteries should be effected generally successively, by one or two batteries at a time, so that the fire should not be interrupted. *The movements from one position to the other should be carried out with rapidity, but with order and regularity, and the interruptions in the action be reduced to the shortest possible.* Every accident in the ground affording cover should be taken advantage of in making a change of position undertaken in view of the enemy. Consideration should be given to the direction of the fire of the batteries in rear in carrying out the movement.

§ 52.

Replacing Ammunition.

462. The replacing of the ammunition expended in action is effected

by battery arrangement according to § 20. They should have made known to them the positions of the ammunition reserve and of the division ammunition park.

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§ 53.

Conduct of the Ammunition Reserve.

465. The placing and movement of the ammunition reserve will, in general, be regulated by the commandant of the division.

The commandant of the ammunition reserve acts according to the provisions of § 21.

He must on no account omit to keep himself informed of the position of the division ammunition park. He must ascertain the best road by which to reach it, and keep up a constant communication with it.

* * * * * *

468. Any battery detached to act in a distant part of the field, should have an ammunition reserve sent after it to wherever the ground and the state of the action may dictate.

* * * * * *

§ 54.

Escorts for Artillery.

* * * * (See § 24 generally.)

Section 5.

Honours and Salutes. Marching Past.

Section 6.

§ 58.

Procedure in the Manœuvres of a Division of Batteries.

497, 498. * * * * * *

499. The principles of the exercise of a division of batteries being detailed in § 31, it is only necessary to make the proviso that the separate movements are not to be indicated beforehand, nor should they be allowed to have the character of movements got up for show, but they should always be carried out with the single purpose of the development of an idea based upon a distinctly assumed offensive or defensive object of action.

500. The rules given for carrying on the field manœuvres of a battery in § 30, apply generally to the division of batteries also.

501. Every divisional commandant should remember that in real

service the several batteries would generally receive their orders from him verbally, as to taking up positions indicated to them for a particular object at a particular moment. The most thoroughly intelligent control on the part of the divisional commandant is therefore as necessary to ensure the satisfactory co-operation of the whole in the pursuit of the common object, as the clever handling of their commands by the battery commanders and a sound training among the men.

502. Every field manœuvre should be based on a practicable tactical supposition, and aim at the realisation of a clearly defined idea. The commanders of batteries and of the ammunition reserve are always to be informed before commencement of the movements as to the idea of the action and of the subsequent operations, and they should in turn acquaint their subordinates.

503. In all movements and taking up of positions the battery commanders must be accustomed to avail themselves to the utmost of the advantages of ground, and should always keep in view the requirements of the general combination and the common object.

504. The following succession recommends itself as suitable in practice of field manœuvres:—*The assembly of batteries* in a common rendezvous at a fixed time, but by different routes; *the forming up of line* from column of route or column; *the advance into position for action; the reinforcement* of single batteries in action, &c. Later on, the division can be treated as divisional artillery, the other arms being supposed. Here the distances and intervals in the order of march and in line should be kept as closely as possible to the real intervals, &c. The batteries will be summoned by the adjutants or the orderlies, and shown to their ground by them.

In this manner the commandant of the division exercises himself in giving orders, the commanders of batteries are practised in taking them up and executing them, the adjutant and the orderlies also in the transmission of short verbal messages. Finally, the division will be regarded as *reserve artillery,* and will practice the advancing of batteries simultaneously by different parallel roads to a common position, and also changes of position.

505. In field manœuvres the actual ground should be accepted in its configuration as it is; all complicated suppositions should be avoided; the movements should be executed in the simplest forms; and flank movements, which rarely occur in actual service, should also be but rarely exercised.

506. Batteries should practice the exercises referred to in para. 261, when in positions in action.

507. When the manœuvre is carried out by two divisions of batteries opposed to one another in the spirit of para. 262, the movements should be made to cease when the position which probably will decide the action has been taken up. The commanders and officers, &c., should repair to the enemy's position, and from thence judge of the bearings of their own position. The concluding discussion on the manœuvre should be held when both sides are present.

CHAPTER III.

Regulations for the Reserve of Artillery of an Army.

Section 1.

§ 59.

Composition.

Précis.—The reserve of artillery is composed of two or more divisions of artillery, under a colonel. * * * * * * The ammunition reserves remain, as a rule, with their divisions.

§ 60.

Formation and Telling Off.

511, 512. * * * * * *

513. The divisions composing the reserve artillery of an army will always be named after the commandants in charge of them.

§ 61.

Duties of the Commandants.

514, 515. * * * * * *

516. *The commandants of divisions* should place themselves where they can best supervise and control their own batteries, and also be readily accessible to receive the orders of the commandant of the whole.

517. *The commandant of the reserve artillery* remains, as a rule, in the centre of his command. Being, however, not tied to any spot, he should leave word, in case of protracted absence, where he is to be found. Somebody should be left behind, in the place he has last quitted, to send any reports which come in after him.

§ 62.

Command and Issue of Orders.

518. Where two or more divisions are united, it becomes no longer possible to order the movements on all sides by word of command. The commandant then makes use of his staff in transmitting orders, either verbally, or in important cases even in writing.

519, 520. * * * * * *

§ 63.

Movement and Formation for Action.

521. *In the employment of several divisions of batteries as a mass, the character of its use as a principal arm should be constantly maintained.*

522. * * * * * *

523. As a guide to its mode of employment, it can only be said that *artillery, when to be employed en masse, should come simultaneously and unitedly into action; it should avoid fire at long ranges; should move to within a thoroughly effective range of the enemy, and concentrate its fire on a common object.*

524. In the attack of an enemy who is unshaken, where a formidable resistance is to be expected, a preparatory position may be taken up at an intermediate distance, and the advance to the decisive range be carried out only after the enemy's artillery has been cannonaded.

525, 526. * * * * * *

527. Before the action, the commandant of the reserve artillery should be guided generally by para. 421. His weightiest care is always to have the most *thorough knowledge possible of the ground,* that he may direct the divisions how to avoid obstacles, and be able to lead them forward at the right time, and deploy them in the right places.

In the reconnaissance, a general idea of the ground can be obtained from elevated points with the aid of good maps. The practicability of roads, and the amount of room afforded in the contemplated positions has to be ascertained by the commandant, by the aid of his staff and of the adjutants of divisions, who are sent to examine them.

* * * * * *

530. *Since safety against direct attack* in a direct sense is an indispensable condition in the employment of a large mass of artillery, the movement and the position in action of the artillery reserve should be covered by large bodies of infantry or cavalry. The orders for their movement, &c., should proceed from the commander of the troops. The commandant of the artillery reserve should, however, always take into consideration the protection which he will require, in order to be able to prepare for the execution of the task he is charged with without hindrance, and to carry it out with vigour.

531. * * * * * *

532. *The position in action should not present an unbroken line.* It is even advantageous to form up in several separated lines, particularly when the enemy's masses can thereby be taken obliquely, and when large intervals can be left free for the advance of the other troops to the attack.

533. The fire of the artillery reserve should be crushing; carrying confusion into the enemy's order of battle before he can find time and means for counter measures. The saving of ammunition, and even considerable losses, must be disregarded when great objects are to be attained.

* * * * * *

537. * * * * * * *In case of retreat* the commandant names those divisions which have to cover the further retreat; indicates the positions they should occupy, and acquaints each with their lines of retreat, so that no disorder or entanglement of the different columns should ensue.

538. When a *large mass of artillery is assembled during peace manœuvres* for a common object, *manœuvres* should always be practised, and *not drill.*

The commandant should change the manœuvring ground as often as may be. He should give out the necessary suppositions for the strength and position of our men and the enemy's forces, and carry out the movements according to a governing idea. The commandant should communicate this idea to all those holding independent commands under him. The movements which are to follow are either to be made known in general terms beforehand, or, if the commandant reserves the issue of such orders for himself, they should be explained at the close.

Section 2.

Regulations for Parades of Large Bodies of Artillery.

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Appendix.

Formation of Ammunition Columns.

FINIS.

Vienna, 1872.

Authorised Translation.

ON SIEGES,

BY

KRAFT, PRINCE OF HOHENLOHE-INGELFINGEN,

MAJ.-GEN., INSPECTOR OF THE IInd ARTILLERY INSPECTION.

"First ponder, then risk."

TRANSLATED FROM THE GERMAN FOR THE ROYAL ARTILLERY INSTITUTION,

BY

CAPTAIN F. C. H. CLARKE, R.A.,

TOPOGRAPHICAL STAFF.

INTRODUCTION.

THERE are a great many instructive lessons to be gained by a study of the attack and defence of fortresses in the last campaign. Twenty fortresses in all surrendered to the German arms, and there were only two which were not reduced—viz., Langres, which was masked, and Bitsch, which, from its position, did not allow of a serious attack in form.

The twenty sieges, which were continued until the surrender of the fortresses, exemplify practically all the different conditions with which the science of the subject had made us acquainted, from the blockade and the surprise to the regular formal siege. Although the information at present available is not sufficiently detailed to permit of the construction of any definite theory with regard to the future conduct of sieges, yet it is very certain that the method of siege hitherto in force is no longer applicable in the present day. Consequently everyone who reflects on these matters forms his own opinion on what should be done in future, and bases it on all he has experienced, heard, or read during the last war.

In the following pages I will give my views on this subject, but first of all would premise that they have no claim to be considered complete, and, from the insufficiency of my own knowledge of many of the facts of the last campaign, they must be subject to change. I would further remark that I have assumed the existing siege *matériel* as the type, and have refrained from speculating upon any new inventions, so as to confine myself exclusively to the subject under its present conditions.

INVESTMENT.

Before the siege of a fortress can be resolved upon, we must be victorious in the field; and in order to be able to capture the fortress, either a numerical or moral superiority is necessary on the part of the besieger.

After this victory in the field has been gained, the besieger may march upon the fortress with the intention of opening the siege; but before the siege *matériel* can be brought up and arranged with a view to commencing the attack, the fortress must be invested on all sides.

If the defender is capable of assuming the offensive, he will endeavour to hold as much of the ground in front of the fortress as possible, so that the armament of his batteries may be completed with the least molestation from the enemy's fire, and will occupy and entrench himself temporarily on any points which may be suitable. The besieger will endeavour to prevent him from doing so, and to throw him back into his works. Engagements in the field on a larger or smaller scale will ensue, terminating with the investment of the fortress. To effect this the besieger establishes himself firmly on those positions offered by the ground, entrenches himself with his field guns within temporary fortifications, and thus cuts off the defender's communication with the surrounding country.

The theoretical question then arises, "Where, and at what distance from the works of the fortress, should these positions be selected?" In practice, this question has received many different solutions. On many occasions the positions were so close that the siege artillery commenced its fire for the reduction of the fortress as soon as it was mounted in them; others were at a greater distance. In reality, the choice of position is dependent partly on the ground, partly on the energy with which the defence is conducted.

There can be no question that an energetic besieger, merely from his superiority, should be able to throw back the defender into his lines, even if in doing so his numerous field guns are involved in a struggle against the enemy's garrison guns as long as the process of investment lasts; the field artillery meets with some loss, but will certainly not be annihilated. But it is another question whether we can maintain ourselves in this position for the requisite time without being exposed to great loss in consequence of the close proximity of the garrison guns, and also to the excessive exertion consequent on a perpetual state of readiness for battle, and thereby endangering the result of the siege; for field artillery lacks the requisite ammunition to keep up a constant fire day and night. If the siege artillery, with the necessary supply of ammunition, were at hand, so that it could be placed in position and in readiness to open fire in one or two days, then we should hold provisionally with our field guns those positions which we have won by throwing the enemy back on the fortress. This is, however, only very exceptionally the case. On the contrary, days—even weeks—may pass before the first shot from a siege gun is fired, and until then we cannot engage our field troops within the most effective ranges of the fortress. Consequently, less forward positions are sought for, and only the outposts are left in front, their supports and reserves being drawn back more or less according to the ground.

There is nothing to prevent the defender from now driving in our outposts on the main position, in order to re-establish himself in front of the fortress. The besieger should oppose this, and throw him back into the fortress. In doing so, many engagements, more or less severe,

will take place, which, unless the defender has lost all energy, must be carried so far that the latter is only allowed to occupy so much of the ground in front of the fortress which, if occupied by the besieger, would expose the main body of the outposts to the fire of the artillery of the fortress.

It may be assumed, therefore, that the defender finally succeeds in pushing forward his outposts to a distance of from 1000 to 2000 paces beyond the fortress, whilst the besieger's line of outposts can seldom hold its position within 3000 paces, and as a rule is even further distant. In short, the besieger eventually remains at a distance of from 2500 to 4000 paces.

Instances have occurred in the last campaign where the defender has scarcely ventured out of the fortress after its investment, and the besieger has been thereby enabled to establish his first batteries within 1800 paces. We will, however, in theory assume that we are opposed to an enemy capable of an energetic defence.

Choice of the Front of Attack.

During the investment and the engagements resulting therefrom, a reconnaissance is made of the fortress, for the purpose of selecting the front on which the attack is to be directed. In this matter, certain points due to recent inventions are of decisive moment, which in no way affected former sieges.

Firstly, the *matériel* which is used in sieges is so considerable that it is of great importance to have possession of a railway leading from the base of operations to the siege park. Not only the weight of the guns, but still more the weight of ammunition expended daily, which has to be replenished from the rear day by day, make this means of communication very desirable. (At Paris nearly 3000 *centners** of ammunition were fired away daily; at Strassburg a still greater number).

The situation of the railway at our disposal will therefore have considerable influence on the choice of the front of attack, especially in large fortresses; and it may happen that we may prefer to attack a stronger front because our work will be made easier by the greater abundance of *matériel* brought by railway, than a weaker front which has to be supplied by land transport. In smaller fortresses this question is in certain cases of less importance—if, for instance, the road leading past them is not too far distant and inconvenient. But the larger the fortress, the more important the question; and it may be asserted that a large fortress favourably situated, which has all the resources of art at its disposal and is well defended, can only be captured by a regular attack if the besieger has a railway at disposal, because he can by its means alone provide a superiority of *matériel* over the enemy.

Another point which has recently affected the choice of the front to be attacked, is the increased effect of our guns, both as regards their range and destructive power. Hitherto, those fronts which were deemed unassailable were not strongly protected, and works which once com-

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* About 148 tons.

manded the entire ground in front, can now be themselves commanded from heights to which, on account of their distance, no attention was paid in the original design of the fortress. Besides, all the fortresses at present in existence were not designed to withstand the effect of our modern siege guns. The defender may remedy this evil in time of war by temporary works, and in time of peace by improving the fortresses, but he will not entirely remove it; because no state is sufficiently rich to be able to raze all its fortresses to the ground, and the improvements can never be anything else but patchwork. Moreover, it is no longer possible to hold the ground within range of the guns of the fortress free from cultivation; because this *rayon* has enlarged so much from an extension of the range of the guns, that the state would not have the means to do so. From all that has been said, fronts of fortresses are weakened as regards their capability of resistance; and where at one time only, perhaps, a single assailable front could be found, we can now find many, and it thus becomes more easy to seek out a front with available railway communication. Hence we see that the relative position of the line of railway carries still more weight in the choice of the front for attack.

Lastly, there is another point which has become of importance in the choice of the front for attack in the present day, and that is the one which we have previously mentioned—the impossibility of holding the ground within range of the guns of the fortress free from cultivation—and that, in consequence of the great effective range of artillery, points and positions can always be found from which the fortress can be bombarded, and in and behind which the besieger can operate unseen by his adversary. The relative situation of such points to the fortress, and the possibility of securing them during the investment, will have great influence in determining the front for attack; and owing to this circumstance, fronts which have been hitherto considered unassailable are, in the present day, the more favourable for attack.

Duties of the Besieging Troops.

The front of attack having been decided upon, the plan of attack must be settled, the necessary preparations made, and the duties of the besieging troops regulated.

As regards the arrangement of duties, next to nothing is prescribed in our regulations and text-books, and consequently different methods have obtained at the various sieges. As a general rule, the duty of issuing the orders on this subject devolves upon the general in command of the besieging forces; the artilleryman and the engineer, however, may make proposals affecting their respective branches. Field troops are almost always necessary to second the arrangements both of the artilleryman and of the engineer, and the companies of artillery and engineers employed in the siege become fresh additions to the already organised units of troops, and have to be distributed and rationed. If both these matters are arranged by army head-quarters, the general commanding the siege troops becomes burdened with a lot of executive detail which should never be brought before him, because it has nothing whatever to do with the

chief duty of directing the siege. Again, much time and power would be thereby wasted, and the danger incurred that many a favourable opportunity might slip by unutilised because it cannot be seized in the nick of time.

For instance, taking the case of a large front of attack, if orders as to the rationing and distribution pass from army head-quarters through the senior officer of artillery to the artillery, much time will be lost; and if the engineers and siege artillery have to send in demands to army head-quarters for every man they require from the infantry, they must take into account the time necessary for issuing the order in sending in their requisitions, which in a large body of troops may be as much as forty-eight hours. If it turns out in the course of the siege that the enemy takes a false step, or has become weakened by our fire, this may be turned to account by setting some spades to work, but this will not be possible on the succeeding night, and by the second night the opportunity will probably have passed by, on account of the counter measures of the enemy. The same holds good should the fire of the besieged have pressed heavily upon the besieger at some point or other, necessitating the throwing up of considerable cover for protection; this would have to be left undone until the next night, by which time the whole of the batteries of attack might have been destroyed. Moreover, the artillery and engineer troops employed in the siege are in perpetual conflict with the field troops if they are rationed and distributed by direct orders from army head-quarters.

On many occasions the arrangement has obtained of incorporating the artillery and engineer forces employed in the siege with the tactical unit of the mixed arms (the Division), and assigning them to it for all matters connected with distribution, rationing, jurisdiction, and requisitions for working parties. The Division, which had one or two divisions of artillery under its orders, supplied the working party required by these garrison artillery companies from the field troops on the principle that the following was the maximum effort of which each man was capable:—one day outpost, the next day working party, the third day rest. If the requisitions for working parties by the siege artillery or engineers were in excess of the amount the Division could supply, taking the foregoing rule into consideration, application was made to their *corps d'armée*, &c., for assistance from the other Divisions. It should here be remarked that the main body of the advanced guard and the reserve to the outposts may be frequently employed perfectly well for throwing up earthworks, when they are not taking part in the relief of the posts—if, for example, the work to be done lies within the *rayon* in which the reserve is posted. A closer union between the siege troops proper and the field troops is established by assigning them to a Division, and a greater interest on the part of the field troops in the progress of the siege works. I would therefore always advise such an organisation, and the force of siege artillery should consequently only be placed under the direct orders of the general in command when the fortress is so small that the siege army does not exceed the strength of one Division.

The proposed plan, where it was carried out, moreover solved practically, in the most advantageous way, the question of the share borne by

the *personnel* and *matériel* of field artillery in sieges; for when the Division commanders did not want their field batteries in positions, the officers, N.C. officers, and men were employed to aid the siege artillery; and it frequently happened that a whole field battery, with the aid of a working party of infantry, built a siege battery, and employed its horses in dragging up the guns with which it was to be armed, so that the garrison artillery had only to superintend the armament and serve the guns. If the field artillery of the Division was insufficient, the Division applied to the *corps d'armée*, which gave a working party from the corps artillery.

It ultimately resulted that seven to eight guns per company of siege artillery were permanently kept in action, whereas in those cases where there was no such organisation of the duty, only four guns per company could be maintained. In no case, however, were any men supplied by the field troops for the service of the siege guns, but only officers of field artillery on some occasions.

It is only natural that many circumstances will influence these arrangements differently, and necessitate other measures—as, for instance, in sparsely populated districts, when we spread our cantonments more widely, and in populous districts keep them more closely together; or in a good season, when we can canton, bivouac, and encamp; or in bad weather, when we may have to build huts. At all events, the greatest importance must be attached to an early organisation of the interior duties and of the arrangements for command, so that orders may be carried out as rapidly as possible. Only when this is the case will everything work smoothly, and the siege be conducted with energy. In all former regulations, text-books, and historical accounts of sieges, sufficient value is not attached to organisation; yet the proper conduct of the siege is as much dependent upon it as the correct employment of field troops upon a proper order of march and a well-regulated distribution of troops.

In conclusion, it may be remarked that perfect harmony in the arrangements of the artillery and engineers is pre-supposed. This can only be permanently secured by the daily conference of the commanding officers of the two special arms, and their mutual agreement as to the works to be carried out, and the proposals to be submitted to the general in command of the siege. The importance of having their quarters and offices close together cannot be overrated.

If the troops of the special arms are incorporated with the Divisions, as before mentioned, the senior officers in command of those troops should assume the chief direction of the works, and, like the chief commanders of the engineer corps and of the siege artillery, act in concert by constant personal intercommunication.

Determination of the Plan of Attack.

A detailed plan of attack can no longer be drawn up, and the work of the first night, first day, and so on, predetermined, as in the time of the great Vauban. In consequence of the increased range of fire-arms, we are compelled in the present day to remain at such a distance from

the fortress that we are unable to reconnoitre and see all the points bearing upon the problem; and we cannot, in a previous arrangement of the plan of attack, reckon with certainty upon being able to determine the point where the breach is to be made and the fortress stormed. Yet from the very commencement we must have a clear idea in which direction (approximately) we intend to enter the fortress, because the extent of front of the siege works and the measures for capturing other works are regulated by it. The situation of the siege park, and the position of the intermediate depôts, &c., are especially guided by it.

The plan of the siege will no longer, as of old, commence with the arrangements for opening the first parallel; for with the present effective range of fire we cannot now commence by opening a parallel at 800 paces from the fortress, and, on the other hand, the fire at a closer distance is now so annihilating and decisive, that the principal work is done when we arrive within 800 paces, and the decisive result will not be very long delayed when that point is reached. Taking as the starting point the general situation of the intended breach, the plan of siege is provisionally limited to those steps which have to be taken for opening the first parallel. We shall revert to this when speaking of the conduct of the siege.

Preparations for the Siege.

The preparations which the investing troops must take in hand before the siege artillery arrives, consist chiefly in preparing the brushwood and wood, in forming the siege park and the intermediate depôts; taking for granted that the entrenchments thrown up by the investing troops for ensuring the investment against sorties are not neglected.

The preparation of the brushwood, wood, &c., was undertaken by the siege artillery in very much the old way, the entire working party being detached to a certain point where they worked under one commander. This arrangement entailed many disadvantages. In the first place, the working party had at times to march some considerable distance to the spot, and their time and energy were thus wasted; again, they were withdrawn from their cantonments and posts, and were consequently not where they would be wanted in the event of a large sortie. The consequences were that working parties could only be told off from the reserves, and therefore much less work was done. Lastly, the constant marching off of troops in the direction of the place of work, disclosed the position of the siege park to the enemy.

In consequence of this, the *matériel* in question was provided in a different way at other places. The troops received the order simply to deliver daily so many fascines, so many gabions, &c., at the points where the parks of *matériel* were established; how and when the troops were to work was their affair. This arrangement can be very easily carried out as a part of the previously proposed organisation of the whole duty. The places for collecting brushwood should naturally be selected in those cantonments occupied by batteries or companies of field pioneers; the field artillery (field pioneers) execute the work, receiving assistance

from those infantry cantoned alongside of them. Under these circumstances, everybody is in readiness for fighting. If there is a sortie and the troops have to fight, their work for this day remains in arrear. The teams of the batteries, hooked into country wagons, transport the *matériel* as it is made to the depôt.

In this way it became possible to collect fascines, &c., on the third day after the issue of the order. On the first day the *matériel* (fascine-trestles, fascine-chokers, &c.) was collected, on the second day the fascines were made, and on the third delivered.

If there are not sufficient men belonging to the siege artillery and engineers available, the field artillery and field pioneers must form temporary park-administrations (*Park-Directionen*) to organise the *matériel*, and to arrange and administer it. The daily quantum to be delivered must be so calculated that all the *matériel* for the first throwing up of the batteries and communications up to the last night of the building of the batteries preparatory to opening fire, is held in readiness for use. A reserve of 25 per cent. should be provided against contingencies.

The choice of the point at which the supplies of brushwood are to be delivered is of great importance, as it depends on the place determined for the siege park, and any further transport of the brushwood after it has once been collected to some other place is a very endless work, which happens just at the time when the teams are more wanted for other purposes, and the course of the siege may be delayed in consequence.

The siege park should be so placed that it is well out of range of the enemy's guns, and should therefore, as a general rule, be situated not much less than a German mile* from the enemy's most advanced work.

The brushwood depôts are the nearest to the enemy, then comes the gun park (including machines), then the ammunition depôt, and furthest off, the laboratory store and powder magazine. To avoid unnecessary labour in transport, the gun park and the ammunition depôt should be situated close to the railway.

If the siege park lies at some distance from the ground on which we are about to open our attack, it follows that a great many horses are necessary to keep up the communication, and these horses should be exclusively for the use of this park. This circumstance, and the necessity of erecting workshops in connection with the siege park of very varied kinds, make it desirable that the park should be situated near some large town which offers sufficient accommodation for men and horses. If this condition cannot be fulfilled, a considerable number of huts must be built.

It is of course assumed that the siege park should lie tactically protected—that is to say, behind the most rearward lines of investment—and when necessary it should be surrounded with temporary works or field fortifications, so as not to be exposed to a sortie.

Another preparation which can and should be made before the arrival

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* A German mile is equal to $4\frac{1}{2}$ miles English, approximately.—Tr.

of the siege artillery, is the building of all those batteries which can be built unseen by the enemy (masked).

In consequence of the great distance of the investing troops from the fortress, and the impossibility of reserving all the ground in front of the fortress free from cultivation, there will always be strips and points on which the besieger, unseen by the enemy, can build his batteries—of course within the *rayon* guarded by his outposts. These batteries may, perhaps, be screened from the enemy's view by undulations of ground, walls, gardens, hedges, woods, or what not. All such favourable points, after being reconnoitred, might be marked out as sites, provided that the building of the batteries on those spots tallies with the general plan of attack. Their construction devolves upon the field artillery of the besieging corps, aided by soldiers of the line, in accordance with the before-mentioned organisation.

It is of course pre-supposed that the command staff of the siege artillery has by this time arrived, and that the officer in chief command of the siege has approved of the proposals for the sites of the batteries.

It is now time for me to speak, first of all, of the construction of batteries.

Construction of Batteries.

In the twenty sieges of the last campaign, fully 500 batteries were thrown up. The descriptions varied very much. None were built according to the old regulations, or if they were, they had soon to be altered. This involves no reproach upon the regulations, for the effect of guns is now very different to that on which the regulations were based. The French, who adhered to their regulations in a most pedantic way, smarted for it bitterly, their batteries being speedily dismounted.

I will now mention the main points of those types of construction which were most commonly used, and in doing so will suggest any changes which I believe should be recommended for any future siege, and on what occasions they would be desirable.

1. *Usual form of battery.*

A depôt is organised, the batteries are commenced on the first night, the parapets having a considerably greater thickness than in the regulations (minimum thickness of 24 ft.); between every two guns a hollow traverse with a thick covering of earth, or else a bomb-proof screen between every gun; no embrasure, but merely a trough-shaped indentation on the crest, usually scooped out with scrapers; and a covered space for the detachment close at hand, with arrangements for keeping it warm in winter.

These batteries could not be finished in one night; two at least are required, and more if the ground is difficult. This description of battery is especially to be recommended for those which can be built masked, and are not unmasked until their armament is completed. These batteries will be usually the first which are built, and therefore, if the siege is properly conducted, those which as a rule have to sustain the brunt of the enemy's fire, and they should consequently be of the strongest

construction. Since they are built masked, they will be built on the worst ground—in woods, gardens, on the sites of buildings, &c.

From experience of these batteries, I would wish to recommend the following :—

The coverings of earth should be as thick as possible. If the ground admits of it, the batteries should be made rather more than *sunken;* the hollow traverses should have a considerable covering of earth, otherwise rifled projectiles impinging upon them at high angles of descent go through them. The thickness of earth over the traverses should not be visible above the crest of the battery, or it would facilitate the enemy's aim; consequently the interior space should be constructed lower than the interior of the battery, provided the drainage arrangements permit of it. The same holds good as regards the shelter for the detachment. On some occasions, wood timbers have been laid from the bomb-proof screen to the parapet, to form a shelter for the detachment. This is a fatal measure, because splinters of wood increase the losses; and again, beams and planks give no protection, and a shell penetrating into the covering has a very bad influence upon the occupiers, as usually there are many men inside, and a man who goes to the place for rest does not like to have his repose disturbed. It is to be recommended, when practicable, that the interior space should be deepened when the battery is finished, and that the platforms alone should remain as they were. The men thereby gain in cover. As a general rule, let them dig as deep as they can. Instances have also occurred where no embrasure-like troughs have been made, but the crest has been sloped from within outwards parallel to the angle of projection of the gun. This is only suitable in light soil, otherwise the rain-water draining from the crest inundates the interior of the battery. It has been found useful to construct, when possible, two expense magazines (*pulver-kammer*) per battery, as in the event of one being blown up the firing need not be suspended.

2. *Siege battery on the field type.*

The above term was applied to those batteries which were made for a certain number of guns by merely throwing up a revetted entrenchment. The guns, mounted on siege carriages, fired *en barbette;* they had expense magazines. Such a battery is easily thrown up in a night, but it gives little cover for men and guns, and must be completed on subsequent nights by deepening the interior of the battery, constructing hollow traverses, bomb-proof screens, and shelter places. When the battery was exposed to the enemy's infantry fire, or was under shrapnel fire, the occupants were at times compelled to heighten the crest of the parapet between every two guns by superimposing one, two, or even three layers of fascines. They formed, however, small embrasures, which facilitated the enemy's aim.

As a general rule, this construction of battery was very convenient when it was desirable to open fire quickly, or when the battery had to give a fire in all directions, and when it was exposed to sorties, and no emplacements could be established. It is, however, at the same time necessary so completely to surround the enemy and crush him with a superiority of fire, that these batteries, constructed with but little cover,

may silence him soon after the firing commences, and thus seek their shelter in the effect they produce. If these conditions cannot be fulfilled, such batteries should never be built.

3. *Hastily constructed battery.*

This battery was recommended by the Royal Inspector-General of Artillery before the campaign, and has been much employed. It had the disadvantage that it did not permit on the first day the direction of fire being shifted upon a different object to that for which the battery was built, whereas in the battery alluded to in the previous section we can at any time concentrate the whole of the guns on any point and crush the enemy at that point. On the other hand, the present construction gives more cover from the commencement. On the second or third day, when the battery is completed, this description permits of the direction of the guns being changed at pleasure. The objection was raised in time of peace that too much earth was given by this construction, and more than we knew what to do with. On service there was never enough earth.

I have come to the conclusion that wherever it is possible—that is to say, wherever we can work unseen by the enemy—the first method of construction should be employed. If, when we first place our guns in position, we are compelled to construct other batteries on points visible to the enemy, then these batteries should be built on the third plan, and armed on the same night that we unmask those constructed on the first principle. As a general rule, exposed eminences give favourable ground for working, so that we can reckon upon building and arming those batteries on the same night.

If the nature of the ground renders this mode of proceeding doubtful, a communication to the spot should be constructed soon after the investment. The enemy cannot keep up a constant fire day and night on the communication for the purpose of rendering it impassable. Eventually his fire slackens, and then the besieger prepares and commences the building of his batteries under cover of this communication; so that the completion and armament only take one night.

If we have already considerably weakened and intimidated the enemy with our fire, the second method of construction will be often well suited later on for the more advanced batteries, and may be advantageously employed at the commencement in place of the construction alluded to in this section, when the enemy is well hemmed in, and when we can oppose a great superiority of guns, as by doing so we save the *emplacements* to provide against sorties.

4. *Emplacements against sorties.*

These have not turned out very well when armed with field artillery, as they have only an interior slope 3 ft. in height, and consequently lose much of their *matériel* in course of time. It would be better here to employ the 6-pr. siege gun, for which there would otherwise be no use at the commencement of the siege. Later on, when we get nearer to the fortress, *emplacements* for guns are no longer

required, as sorties are more effectually repelled by infantry fire. There will also be points where mitrailleuses can be more advantageously placed to resist sorties, especially wherever the enemy, making a sortie, is obliged to select definite lines of advance within their effective range.

In general, I would recommend the following principles to be observed:—

In choosing the spot, especially for the first batteries, we must above all things look out for natural screens, so as to deceive the enemy as to the situation and distance of the batteries. Hedges, fences, undulations of ground, underwood, walls, and houses, situated a few hundred yards in front of the batteries make it exceedingly difficult for the enemy to observe the effect of his fire. We have had batteries which the enemy has endeavoured to search out with his fire for days and weeks, but has failed, and they suffered no losses and produced excellent effects.

No opportunity should be neglected of improving the battery and repairing damages when the enemy ceases his fire. The spirit of the Prussian soldier on service is of so aggressive a nature that he prefers fighting in the open to throwing up earthworks. In fortress warfare this predilection must be combated, otherwise we lose too many men.

Well protected posts of observation should be provided for the use of the officers especially, and their propensity for exposing themselves to the enemy's fire should be combated, except when it is absolutely necessary; otherwise we lose too many officers. Although in all the arms the per-centage of loss of the officers was high, it was highest of all in the siege artillery.

We should dig down as deeply as possible into the earth, so as to get more protection from the increased amount of earth.

Prettiness of form, smooth slopes, straight faces and crests, are not only useless but dangerous, because they facilitate the enemy in his aim, and in the observation of his shot.

A battery, when it is seen by the enemy for the first time, should appear just like a heap of earth, of which he can make nothing until its fire clears up his doubts.

The Siege Train and Siege Companies.

During the preparations, the siege train and companies arrive. The gradual arrival depends upon the means of transport. The *matériel* is brought up to the park according to the instructions previously mentioned, and the companies organised.

The strength of the siege train and of the siege artillery troops must be decided separately for each fortress, and, strictly speaking, can only be definitely decided when the entire design of the siege is drawn up. The maximum number of guns must be limited to those which can be employed at one time, with an addition of 10 to 20 per cent. as a reserve for guns and carriages dismounted or under repair. The division into whole and half siege trains (sections) is an arrangement for peace administration, and at the same time a practical distribution for estimating in bulk the siege train according to the size of the fortress.

For such a portion can be at once set in motion, and having the transport for the guns there is no necessity for waiting the definitive decision upon the plan of siege, as any further demands which it may entail can be subsequently supplemented.

In the last campaign we have reduced fortresses with a quarter of the normal siege train, and one fortress (Paris) would have required at least three entire Prussian siege trains if we had wished to employ the formal attack for its capture.

As regards calibres, we require the 9 c.m. (6-pr.) for *emplacements* against sorties, and for effecting lodgments on captured works; the 12 c.m. (12-pr.) for closer quarters and wherever this calibre was large enough, because the transport of ammunition is much easier than for the heavier calibres; the long 15 c.m. gun (24-pr.) for sustaining the earlier engagements on a large scale, and especially wherever the greatest striking power and destructive effect is necessary; the short 15 c.m. gun, in the earliest duels against guns, as a gun for high-angle firing, and at closer quarters as a gun for high-angle firing and for making breaches by curved fire, and for demolitions; the 21 c.m. mortar for high-angle firing at longer ranges, and smooth-bore mortars only when we have not sufficient numbers of 15 c.m. guns and 21 c.m. mortars. The relative proportions would stand as follows, assuming that smooth-bore mortars are not required:—

	per cent.
21 c.m. mortar	10
9 c.m. gun	10
12 c.m. gun	30
15 c.m. gun (half short, half long)	50

besides some of the captured French mitrailleuses.

Assuming that guns of these calibres are available, and that the previously suggested organisation of the interior duties is adopted, garrison companies would be required in the proportion of 1 to every 7½ guns; and the best arrangement would be, to assign to a company (200 strong) for permanent charge, either 15 c.m. batteries of 6 guns each, 12 c.m. batteries of 8 guns, 21 c.m. batteries of 4 guns, or two 9 c.m. batteries of 6 guns. These remarks are made in anticipation, and they are really questions to be solved by the arrangement of duties in the batteries, or in the course of the siege.

Opening Fire.

When the preparations are completed, and those batteries are constructed by the field artillery, with assistance from the infantry, on sites unseen from the enemy's position, the next point to be attended to is the throwing up of those batteries in view of the enemy, and which have to be armed on the same night in which they are constructed; further, to decide upon how many and which of the batteries first built are to simultaneously open fire, and finally on what object their fire is to be directed.

With regard to the last point, the following first principles hold good:—

1. A simultaneous fire must be opened from all the batteries in the

first position. A partial commencement may entail a check, give courage to the enemy, is at any rate a waste of ammunition, and should therefore be avoided as much as possible.

In order to avoid any misconception, the following points may be noted:—

It has often happened that before opening fire on the fortress, guns which have arrived by successive siege trains have been posted for the time being so as to strengthen the girdle of investment.

These guns might have to take part in resisting the offensive enterprises of the enemy, and their fire cannot be said to be participating in "opening fire" of the siege artillery, as it serves another purpose.

2. The fire must not be opened before such a supply of ammunition is at hand that we can be certain that there will be no chance of a cessation of fire from any deficiency. No fixed quantity can be laid down, as it will depend upon the relations of the probable daily expenditure of ammunition to the means of transport, and the distance from which it has to be brought. The besieger must therefore have such a reserve store of ammunition that there is no chance of his running short before more can be brought from his depôts. This is a very important matter, because a cessation of fire from want of ammunition enables the enemy to repair his damages, and acts therefore as a great check.

Great strength of character is required on the part of artillerymen to hold to this principle with unshaken resolution, because everything is impelling them to open fire as soon as possible. No fortress can be taken quickly enough, consequently the whole world clamours for "opening fire," and the world does not think the siege has begun until the thunder of the guns is heard.

The necessary store of ammunition has fluctuated in practice between 300 and 500 rounds per gun.

3. In the earlier maxims upon sieges, a certain number of rounds was laid down for each gun, which had to suffice for the whole siege. This no longer holds good; for if the fortress does not yield after 800 or 1000 rounds per gun, we must go on firing, or else we are beaten off. Measures must therefore be taken for keeping up the home manufacture of *matériel*, so that there may be a continuous certain supply to replace expenditure.

It has happened that fortresses have capitulated just as the besieger's stores of ammunition were exhausted, and there was no prospect of a fresh supply. That was a piece of good luck.

It may happen that the besieger has to run the chance of such a piece of luck happening. It must, however, be remembered—and in theory attention should be drawn to the fact—that if this piece of luck does not attend us, and our supplies are insufficiently provided, the enemy will be successful. The consideration as to whether this risk is to be incurred depends mainly on the commander of the army, according to the well known truism of a still better known authority—"First ponder, then risk."

The position of the first batteries will be determined by the ground.

I have previously explained that in a defence conducted with energy the enemy cannot be prevented from establishing his outposts at distances of from 1000 to 2000 paces in front of his works, and consequently the distance of the first batteries from the works will vary between 2500 and 4000 paces, according to the ground. The batteries are either the long or short 15 c.m. (24-pr.) and 21 c.m. mortar batteries, the number being so regulated that a superiority of fire may be established over the enemy from the first. Where the enemy can be surrounded, and his works enfiladed in their longest line, a smaller number of guns will suffice; where the enemy can only be bombarded by direct fire, a superiority of guns must be striven for. In addition, batteries must be established to drive him away, and prevent him from holding his ground in front of the fortress; as well as *emplacements* against sorties. For the former purpose, 12 c.m. guns (12-pr.) will answer; for the latter, 9 c.m. guns (6-pr.) and mitrailleuses.

The arrangements for protecting the necessary communications and telegraph stations from the enemy's fire must be completed before fire is opened.

The Night of Armament.

In the night before fire is opened the batteries should be armed, and those batteries not yet ready should also be completed and armed, or newly thrown up and armed. We have been sometimes able to arm batteries in the day time, and to commence this some days beforehand, in consequence of the enemy not being able to see either the battery or the communications to it. In the latter case, it seems desirable to commence with getting up the ammunition, and only to place the guns in position on the last day, or on the last night.

The greatest foresight in the arrangements for arming the batteries is necessary, so as to avoid confusion and mistakes during the night march; and every commander of a battery should inspect beforehand very carefully the road which his column has to take, so that no mistake is possible. Especial attention must be paid in those cases where a battery is to be newly built, because mistakes are more likely to occur, and can be less easily rectified.

This undertaking is, generally speaking, more easy in the present day than formerly, owing to the extension of the range of guns; for as our operations embrace wider tracts of ground, the different advancing columns will find a greater variety of roads, and will not jostle one another. Consequently the undertaking has a far greater chance of succeeding; because the columns are further apart, and the enemy is therefore less likely to remark them. If the wind is favourable, we may reckon with certainty that the enemy's outposts will hear nothing at 1000 or 1500 paces. Even if they remark anything, it is always very questionable whether they correctly interpret the meaning of the noise, and even if they do, the defenders must make a great sortie to destroy the work, and will arrive too late to do so; for their reserves cannot remain under arms all night, and must therefore be first alarmed and formed up. The enemy can consequently only disturb the works with artillery fire, which

fire has to be carried on by night without the range having been determined by day, and directed upon points about the position of which nothing definite is known. Such a fire at 2500 to 4000 paces can neither disturb the construction of the batteries nor the armament. The only thing which could cause the failure of the undertaking would be a well combined sortie on a large scale in the direction of the siege works, arranged beforehand for the same night as the arming, which could only be the result of some great chance or else of treachery. We cannot reckon upon either. The best protection against treachery would be to spread false but probable rumours as to the front of attack and the night of armament.

The termination of the night is the signal for "opening fire." It is absolutely necessary that the firing should commence as soon as day breaks, or else the enemy sees the unmasked and newly constructed batteries, and commences his fire before we can. But in the engagement now impending the one who commences has a great advantage in being able to observe the first shots without difficulty, and consequently of making the necessary corrections. Any fortified work which is bombarded on two sides and is hit before it can answer the fire, will have great difficulty in retaining sufficient composure to observe the effect of its own projectiles. Let any man realise the confusion of the artillery garrison, suddenly awakened from its morning sleep by the enemy's fire, and then having to go and serve the guns on a rampart upon which shell and shrapnel are falling like hail.

In these matters, as in war generally, surprise and initiative guarantee half the certainty of success.

On this account a modification in the foregoing principles of opening fire simultaneously from all the guns, may be introduced under certain circumstances. For instance, it may happen that we are disappointed in our calculation about some battery or other not being entirely finished or armed by daybreak. We should lose the advantage of surprise and initiative were we to wait a half or whole day for the last gun before opening fire.

The order for opening fire must be so timed that we can calculate upon all the guns from the first artillery position opening fire simultaneously. When the "opening" is once determined upon, it must be commenced on the appointed day as soon as there is light enough to see and to make corrections, although certain guns or batteries may not perchance be ready.

Duty in the Batteries.

Before the night on which the batteries are armed, precise instructions should be issued by the artillery with regard to the duties in batteries, reliefs, and reserves of ammunition. There are maxims and regulations on this head, but the most important should be determined on the spot, because they must be regulated by circumstances. Attention may here be drawn to some points:—

Reliefs must take place while it is dark, therefore in the evening or early morning. The early morning relief has the advantage that the

men get the range by day, and on the succeeding night have got the necessary information both for carrying on the fire by night, and also for any extraordinary occurrences. On the other hand, it entails the disadvantage that the relief gets a disturbed night's rest before it comes on duty for 24 hours. This is especially so in winter, and it then comes so hard upon them that the men cannot hold out for so long when the cantonments are at any distance. Preference should therefore be given in most cases to relieving them in the evening. It is not desirable to relieve all the batteries at the same hour, as the enemy will soon remark the time at which the fire ceases in the evening, and will commence a heavy fire at the time when the double number of men gives him a double number of targets.

The daily expenditure of ammunition should be fixed by an order. A daily allowance of 50 to 60 rounds per gun gives a very brisk fire; more than this has generally not seemed desirable.

Every commander of a battery is held responsible that this expenditure is not exceeded, and he has to justify himself for any larger consumption by an explicit order to that effect, or by some very special circumstance. In order to avoid any cessation of fire, twice the daily consumption is stored in the battery magazines. The men forming the new relief bring with them from the intermediate depôts the prescribed daily allowance to replace the expenditure. If the consumption has varied, the commander of the battery who is relieved reports to that effect, and the next relief brings up a greater or less number of rounds.

The superintendence of duty and telling off the officers and non-commissioned officers to the batteries, has varied according to opinion, requirements, and the number of officers and non-commissioned officers present. At the commencement of a siege there is always a tendency to employ too many officers and non-commissioned officers. The predilection for fighting on the part of those engaged, and the desire of distinguishing themselves, rather fosters it. Officers and non-commissioned officers, however, are much more exposed than the men, because they have to move about to look after and regulate matters and observe the effect of their guns—in short, they have constantly to move about either partly or entirely exposed. Moreover, with their responsibility and the precautionary measures they have to take, they are more mentally engrossed than the men. If too many men are employed at a time, the losses will soon be very heavy, both on account of the enemy's fire and the over exertion, both mental and bodily. It is therefore desirable at the outset to remember that no more of the superior officers and non-commissioned officers should be employed than is absolutely necessary. One officer per battery has been found sufficient to command it; but it has not infrequently happened that we were obliged to place a serjeant-major or serjeant in charge instead of an officer. A field officer, or perhaps a captain as substitute, supervises a group of batteries which from their position and communications permit of this arrangement.

As often happens in life, we have in the last campaign made a virtue of necessity in this respect, and have hit upon a very useful arrangement which I should like to see retained, even if the necessity should no longer exist. I allude to the circumstance that the artillery

received two natures of gun—the 21 c.m. mortar, and the short 15 c.m. gun—which were entirely unknown to the corps, because they were only just introduced by the Experimental Committee. The officers who were acquainted with these guns were sent in consequence to the different sieges to afford instruction in their use, and they supervised the working and service of the guns and made the necessary corrections. They went from battery to battery, and trained them one after the other.

This arrangement of having instructors I would fain see retained, although slightly changed in form, according to the degree of the men's training, and their acquaintance with the gun. By having an instructor attached like an adjutant to the field officer of the day, we are enabled to give the command of batteries to individuals who are not thoroughly well up in artillery duties, but who can be relied upon to carry out any orders with which they may be entrusted.

Preparations for the First Parallel.

Subsequent measures will have to be made dependent upon the course of the first day's engagement. They cannot be determined upon theoretically, and in the present day they are more subject to uncertainty than formerly, because we are further from the enemy, and therefore as a rule do not have such precise knowledge of him. If our estimation of the enemy proves correct, and our batteries are properly constructed, we shall establish in the course of a few hours a decided superiority over him. At the same time, the batteries told off for the purpose cannonade the enemy's positions outside the fortress, and direct their fire chiefly upon his reserves (*replis*) or upon any buildings in which he may have entrenched himself. The enemy has sometimes been driven back into the fortress by this fire alone, but, as a rule, a special action between the outposts will be necessary before this result can be attained. Whether this action should be undertaken on the first evening, while the impression of the first day's bombardment is fresh, and its effect utilised, or whether further measures are necessary; whether this action is to be simultaneous over the whole front, or partial; whether the enemy is to be thrown back into the fortress, or whether it is more advisable to be satisfied with smaller successes, and gain ground piece by piece, depends so very much upon circumstances, upon the ground, and upon the moral condition of the enemy, as well as upon the impression made by our fire, that no definite rules can be laid down. Only one point must be laid down in the most absolute way: in all actions the outposts must be provided with a considerable amount of entrenching *matériel*, so as to be able to make good any advantage which they may have gained. Plenty of spades should be taken, because from that time forth the only available means of cover is that which the earth affords. Walls, gardens, fences, hedges, houses, should only be used for communications, so that the enemy should not see us. If the enemy finds us out, these objects afford us no cover against his heavy guns, and the *debris* shot away only increases our losses.

If the general in command of the siege deems it advisable to throw

back the enemy at once within the lines of the fortress, he will call up the field artillery of the siege troops to take part in the action.

The decision as to whether the one action is preferable, or whether the ground should be gained piece by piece, depends upon circumstances, like all great decisions in war; but if the defender is driven back within his lines by an effective fire from the first artillery position, the investing troops should not allow him to establish himself again on the ground in front of the fortress, for they are supported by the fire of their siege guns more efficiently than the defender is by the guns of the fortress. Driving him back by a general action offers the great advantage that we advance more quickly; the only thing of which we must be certain is the success of the action.

Soon after the fire is opened, the besieger will perceive a considerable advantage due to the fire alone. He is able to see and reconnoitre better, because the enemy's attention is entirely taken up by the heavy pressure which the batteries exert upon him, and the enemy's observers are driven away from many points. It will therefore be possible early on the day of the first artillery engagement to form our resolutions as to the details of the subsequent measures we intend to take.

An energetic defender will, before the fire is opened, have determined upon the actions for which he must prepare himself, and have decided upon the points on which he proposes, when the struggle commences, to take up fresh offensive positions as a surprise to the besieger. This will be still more possible if the fortress is surrounded with a girdle of detached forts, between which the defender constructs his batteries. Moreover, we must be prepared for the fact that we have no precise knowledge of the fortress, and the enemy can throw up lines and works which had not been calculated upon. Both of these measures might inform the besieger, either on the first or on one of the following days, that his first artillery position was not sufficient, and that he must build and arm more batteries, until he has finally established a complete superiority. An energetic defender, with fair means at disposal, will be constantly appearing at fresh points with large bodies of artillery, thereby compelling us to build new batteries to crush him; and in this way he can, according to the means at his disposal, delay the progress of the siege for days, weeks, and months. General von Todleben—the most celebrated defender of the present day—herein lays the whole turning point of the defence, which can only flag in the event of the besieger receiving reinforcements, of which the defender is deprived. In this way the superiority is secured, and the fundamental object established with which we started—the superiority, either material or moral, on the part of the besieger; otherwise there would be no siege.

Our superiority will be shown by the fact of the enemy being brought to silence, because he can no longer maintain himself on the ramparts. Although the fire continues night after night, he will endeavour to renew the fight afresh each morning, but not for any time; he may fire a few guns here and there in the course of the day, which we shall have to dislodge, but his entire course of action shows that we are gradually overcoming him.

While this goes on, our outposts are constantly gaining ground for-

wards, entrenching themselves, and opening up communication from their position to the rear. Opportunities will offer for pushing forward those batteries which in their first position were too far off from their objects, and in consequence have not done much execution; and when the nearer batteries are built and armed, those replaced by the new batteries discontinue their fire.

The First Parallel and the Saps.

By gradually pushing forward the outposts, we gain the ground on which the first parallel is to be thrown up.

The opening of the first parallel was, according to the old regulations, one of the chief operations of the siege; and many of the working party had to go out in the open, at the risk of being seen by the enemy, and thereby exposed to great loss. I believe that if the attack is opened from the first artillery position, the first parallel can be established with greater certainty and with less loss, as previously suggested, by gradually pushing forward the outposts up to the ground where the first parallel is to be opened, throwing up shelter-trenches between the positions of the outposts, and afterwards lengthening and widening them into the first parallel. In this way the parallel cannot be established in a single night, but the number of outposts must be augmented night after night.

The proposed plan would have another advantage. The more victorious our arms with the offensive and initiative, the more does the tendency towards the offensive pervade our men to the lowest ranks; hence results such an aversion to digging for purposes of defence or for cover, especially among the infantry, that the latter are prone to consider this physically dirty work as mentally dirty—*i.e.*, it is regarded as unworthy of a Prussian, and in the end he would rather storm entrenchments than build them. This idea takes stronger root if the infantry, as a body, is looked upon merely as a number of workmen placed at the disposal of the engineers. The aversion to work diminishes, however, if the outposts, reinforced by whole battalions, regiments, or brigades if necessary, are charged with carrying out the work, and if, as in the case of the instructors for the artillery, detachments of engineers are divided off among the infantry troops as instructors. Then the whole body of infantry participates in the honour of carrying it out, and takes an interest in it, being nominally connected with it.

I should like to lay down the principle for all further "approaches," that in all cases where it can be done the work should be carried on by pushing forward shelter-trenches, and afterwards connecting them with one another, and that the different sorts of sap (flying or common) should only be used when nothing else would do. In this way the earthworks are advanced more quickly, with less danger, and with fewer losses, especially if the work is carried out under cover of a systematic well-directed fire from riflemen, wall-pieces, and artillery. My idea is not new. It is based on numerous experiences of various campaigns, and I only express the wish that it should be made one of the guiding principles, so that it may be left to the judgment of the general in chief command of the siege, who is acquainted with the energy and vigilance

of the enemy, whether he prefers to open the parallels by one large action or by successive augmentations of the shelter-trenches.

The distance of the first parallel from the fortress depends upon the result of the pushing forward of the outposts—consequently, upon the energy of the defence, and upon the ground. As a general rule, we endeavour to keep up such a vigorous fire from the first parallel with long-range rifles and wall-pieces upon the defender in his works, that his infantry will seldom venture to show themselves with gun in hand. Hence arises the necessity of constructing the first parallel at distances not much over 1000 paces from the fortress. (It is assumed that our infantry is armed with a long-range rifle). In a defence conducted with energy, it is not an easy matter to succeed in establishing the first parallel much nearer than 1000 paces.

The Second Artillery Position.

As soon as sufficient confidence is felt in the protection given by the shelter-trenches which are to form the first parallel, the next step is to establish the batteries of the second artillery position. This second artillery position is necessary, as the first is too far off to guarantee that certainty of hitting necessary for the absolute annihilation of the defensive powers of the besieged. This second artillery position must be more correctly taken up than the first, as regards the situation of the lines and works. It includes batteries for direct, ricochet, and high-angle firing, counter batteries, and batteries for breaching and demolitions.

It must here be remarked that the number of ricochet batteries under the present conditions of artillery and fortification must be very limited, and that almost all batteries have to fulfil different objects, either at first or in course of time; so that it would be well if these names for batteries entirely died out. It would carry us too far to give a special demonstration of this assertion about artillery.

A part of the batteries already pushed forward from the first artillery position will probably form the commencement of the second artillery position; the details as to how and when do not admit of being even hinted at in theory without reference to a special case. In this position the 12 c.m. gun will be chiefly used as a gun for direct and ricochet fire, and the short 15 c.m. gun employed in great numbers for high-angle fire. The 21 c.m. mortar and the long 15 c.m. gun are worked together from the first position, or from the batteries pushed forward from that position.

In constructing the short 15 c.m. batteries for high-angle firing, it should be remembered that some of them will have to form breaches by curved fire and to act as counter batteries or for demolitions with all or part of their guns at a later period of the siege. Batteries of smooth-bore mortars should only be employed when we do not possess a sufficient number of 21 c.m. mortars and short 15 c.m. guns.

The distance at which the second position should be placed will be somewhat less than half the distance of the first; but as its position will depend a great deal on the ground, no definite numbers can be laid down. It may here be remarked that when the batteries have to fire

over parallels, they should be at least 300 or 400 paces from them, so that our own infantry may not be endangered by pieces of the lead coating or other matter; further, that direct fire above 1600 yds., and curved fire for breaching above 1200 yds., requires a great deal of ammunition to produce any decisive effect. Consequently, some of the batteries should be established in the first parallel. At the same time, it may be remarked that curved fire for breaching at high angles of descent has but slight effect at close distances, in consequence of the small charge; so that the batteries for breaching by curved fire should not be built nearer than 1000 yds. on this account. Three or four parallels are established, and the works are pushed forward to the "crowning" under protection of an overwhelming fire from both artillery lines, and from riflemen.

It may happen, but only very seldom if both artillery lines are well placed and work well, that here and there a battery may be necessary between the parallels.

In practice, this was at times necessary when the progress of the siege works so masked some battery that it was absolutely prevented from firing.

The Breach.

As we progress towards the glacis and gain a nearer insight into the works, we can become certain as to the exact position of the breaches, and decide upon the descent into the ditch, and the passage of the ditch. We can also decide if any subterranean warfare is necessary. There is nothing new to be said on this subject.

It will be very exceptionally the case that we are unable to form a breach by curved fire provided we can observe the effects of the shooting of the batteries told off for the purpose from our position on the "crowning," or from any other point. Hence it will seldom be necessary to erect batteries on the "crowning." If it should, however, be necessary to form the breach anew, or to keep it open until the passage of the ditch, the 9 c.m. guns (6-pr.) should be employed in the "crowning" batteries, using a greater expenditure of ammunition to produce the necessary effect. We take it for granted that, as a rule, "crowning" batteries are unnecessary, and that curved fire, corrected if necessary by observation from the "crowning," will do all that is required.

When the breach, the descent into the ditch, and the passage over the ditch are established, the storming takes place.

Storming of the breach will be very seldom necessary if the work is demolished in a proper way—bombarded from both artillery positions, and a hail of shrapnel and shell fire kept up—because there will be no enemy close behind it. If, moreover, we succeed in keeping the defender from coming to within several hundred yards of the breach by our artillery fire, then, as a rule, we can occupy the breach by a rush, and establish a footing therein.

If there are retrenchments, then the lightest guns should be first of all employed on the captured work.

If there are any detached forts, the siege has to be begun anew from the detached forts against the main enceinte.

Conclusion.

It may be hinted, in conclusion, that when we succeed in constructing a short 21 c.m. gun, the effect from our first artillery position will be considerably increased; and that the construction of a short and light 12 c.m. gun would add to the efficiency of our shell fire, and enable us to substitute it for the 9 c.m. gun. Our whole siege train would thus be reduced to three calibres—12, 15, and 21 c.m.—a simplification which cannot be too highly estimated.

As regards curtailing the length of the artillery attack, we may do so whenever the defective energy of the defender invites us to take leaps in our progress, or if the energy of the enemy is on the wane from physical or moral causes. I also reckon the bombardment as a shortened artillery attack. But the bombardment should only be employed when we are in a position to supplement it immediately by a further artillery attack, should the bombardment alone not lead to a capitulation, as otherwise it leads to the triumph of the enemy.

July, 1872.

AN ENDEAVOUR TO DETERMINE

A

TACTICAL BASIS

FOR

THE ARTILLERY OF ENGLAND.

A LECTURE DELIVERED AT THE R.A. INSTITUTION, WOOLWICH, JAN. 3, 1873,

BY

MAJOR H. LE G. GEARY, R.A.

SIR COLLINGWOOD DICKSON AND GENTLEMEN :—

There have been many lectures of more or less ability delivered in this Institution, which have greatly advanced the cause of artillery science amongst us, both in the arsenal and in the field; there has been still more written and presented to us by officers in the papers of this Institution, and in the public press, having the same object, of undoubted value. But perhaps the most cheering and encouraging result of all has been, to prove to the world that there exists in the regiment at the present day, an enthusiasm noble as that which Captain Duncan has lately reminded us inspired our fathers—an enthusiasm which only seems to require right direction, method, and opportunity to land the corps whose welfare we all have so much at heart, so far ahead in artillery science, in the largest sense, as it is already, in material and equipment, ahead of its continental representatives.

I do not propose to-day to occupy your time in recapitulating all the lessons that have been deduced from the latest wars on the continent of Europe; abler heads than mine have already thought them out, and we are proud to know that no abler hands have written them than those of officers of the Royal Artillery. Only as a gleaner in the field in which others have labored do I presume to pray your attention to one deduction which has not yet been discussed so fully as it seems to me to deserve. The Germans and French—and notably the Germans after the campaign of 1866—attributed their shortcomings to the defective organisation of their artillery. All their complaints of artillery fire frittered away, guns not being up in time, opportunities for grand *coups* missed, seem to be referred to that capital defect. The commentators on our side seem to have endorsed this self-accusation. As we have been so happily placed in the spectators' gallery during these events, and have so readily entered into the judgment seat on the actors engaged, I conceive that it would be worse than foolish, worse than a blunder—nay, an unpardonable sin, for us any longer to seek to evade the question as it affects ourselves. I know, Gentlemen, that this question of organisation has engaged the attention of many of us from days dating back to before the collapse of the last French empire; and believe that the

delicacy of the question, and absence of any authoritative expression of opinion on the subject, have alone prevented it being mooted either here or at the United Service Institution. I think you will acquit me of adopting a strained interpretation which the words were not intended to convey, in saying that the following paragraph in the Adjutant-General's report on the organisation of the Royal Artillery presented to Parliament, dated 28th May, 1872, contemplates an interchange of ideas on this matter by the officers of the regiment.

Para. 2.—"You will observe that on most points considerable difference of opinion exists; but, on the other hand, that there is a general unanimity as to its being undesirable to abandon a system which, notwithstanding certain anomalies, has been in operation since 1859, without any real break down, *and without any unanimous suggestion being submitted for the substitution of one on a better principle.*"

Hence, I think that no fitter arena can be found for beating out our ideas on the subject, with a view to arriving at some *unanimity*, than within the walls of our own Institution.

I shall now submit to you, as the answer to the question involved in the title of my paper, that the only true tactical basis for artillery is to be found in a suitable organisation; and further, pray your patience whilst endeavouring to determine what that organisation should be.

First, it must be suited to the conditions of our own army; which precludes subserviency to either French or German model.

Secondly, it must admit of the most skilful employment of artillery in the field. This involves facility of both dispersion and concentration.

Thirdly, it should be simple; so that its requirements may be easily comprehended by the various administrative departments, and by officers of the other arms generally.

Happily—to speak from a higher level than that of the professional soldier—the political and geographical situation of England is such as practically to banish the idea of our having to meet single-handed on the continent of Europe any great power; but we might have to furnish a contingent army. We need hardly anticipate such a change in our national policy as would lead us to try and maintain an army of even 100,000 men on a European theatre of operations. But there is still this necessity of every day—to occupy India in such a manner as readily to repel all invaders, and to maintain our sovereignty there amidst any revolts within our own territory, and to protect a widely scattered colonial empire; further, to assist our fleet in the last struggle, should it ever occur; *pro aris et focis.* These considerations I think tend to shew that our army, and therefore our artillery, requires greater elasticity of organisation than is a necessity for a purely continental power. Concisely, they seek protection from the rigidity of iron armour; we from the more elastic strength of chain. Let us see then, if in organisation as well as in material, elasticity cannot be obtained without a sacrifice of strength. At page 13 "Equipment of Artillery," we read in a foot note:—"It is proposed that a *corps d'armée* consisting of about 12,000 men, should have altogether 48 guns—12 guns to accompany each division of infantry (5000 strong), 12 to be attached to the cavalry brigade, and 12 to be in reserve: thus giving 3 guns per 1000 men." This seems to have been determined *after* the Crimean war; for at the Alma we had only 60 guns

to about 29,000 men—a little over 2 guns per 1000 men, and the whole allied army had less than 3 guns per 1000 men; while at Waterloo we had less than 2 guns per 1000 men. I have extracted from the official account of the Franco-Prussian war, 1870-71, translated from the German by Capt. Clarke, the following information respecting the strength of the corps and divisions of the combatants:—A French division consisted of 13 battalions (one of which was a rifle battalion), 12 guns, 6 mitrailleuses, 1 company of engineers. A corps was constituted of a variable aggregation of divisions, and had an artillery reserve in the proportion of about 12 guns to each division. There was besides a large artillery reserve of some 96 guns for the whole army. The cavalry was organised separately by divisions. A Prussian division usually consisted of 12 battalions of infantry, 4 squadrons of cavalry, 24 guns, and 1 company of pioneers. A corps was constituted of two of these divisions; and besides the above, to one division was added a battalion of rifles, and to the other one more company of pioneers. There was a reserve or corps of artillery to each army corps, of, usually, 36 guns. The total of a *corps d'armée* was thus 25 battalions, 8 squadrons, 3 companies of pioneers, and 8 batteries of divisional artillery, besides six batteries of corps artillery. The cavalry division was organised separately, and had its own complement of artillery. The chief points of difference were, that the French had no unit of organisation beyond the division, while the Prussians had that of the *corps d'armée* of 2 divisions. The whole of the French cavalry was organised into separate brigades or divisions; while the Prussians had, besides such divisions, 8 squadrons at the disposal of each corps commander. The French corps commander of 2 divisions had only at his disposal 48 guns and 12 mitrailleuses, while the Prussian had 84 guns. I apprehend the system which gave a full reserve artillery to the corps commander, was more likely to produce effective results than that which limited his reserve for the sake of keeping a reserve of 96 guns for the disposal of the commander of an army of 300,000 men.

From this comparison of the foregoing establishments, it would seem that for any European operations we shall be compelled to approximate the size of our divisions and corps to those of our neighbours. To oppose a force made up of two *corps d'armée,* comprising 4 divisions and 8 brigades, to one of equal strength, organised as one *corps d'armée,* containing only 2 divisions and 4 brigades, would be to handicap ourselves heavily at the outset. From a recent general order issued in November last, such approximation seems to be contemplated, pointing as it does to divisions of 3 brigades of 4 battalions each. The general order, while going minutely into the subject of infantry movements, is much less explicit as to the cavalry and artillery duties. Indeed, I am inclined to think it would be to the benefit of the army generally were the constitution of a division and *corps d'armée* clearly laid down for us by authority, as it is in the Prussian service; for I apprehend that no general, reading this order, would discover what force of cavalry and artillery he might expect to have placed under his orders, much less how they would be divided between the division and reserve. Until such proportions are definitely laid down, the subject seems properly open to discussion.

For European warfare, I conceive the Prussian organisation to be worthy of adoption, excepting that I should prefer the divi-

sional artillery consisting of only 12 guns per division, and increasing the reserve proportionally; that is to say, the divisional artillery of a *corps d'armée* should consist of 24 guns instead of 48, and the reserve of 60 guns instead of 36. I also think it might be convenient for the cavalry complement of artillery to join the reserve when not actually required to act with the cavalry—a change which the Prussians have introduced since the war. It will be observed that the artillery is calculated at about 3 guns per 1000 men. Now, while there are circumstances under which this proportion might advantageously be increased, there are, on the other hand, times when it would be inconveniently large; and it would be a very serious blunder to encumber an army with more guns than, from the nature of the country it was working over, it could be expected to bring into action. Nor can it be too strongly insisted upon that a gun limbered-up is a weakness and anxiety to an army; an evil which becomes aggravated when the said gun has to be dragged about in the train of an army with a very remote chance of being wanted in action. Therefore, I have advocated 2 batteries (12 guns) per division as the permanent proportion, as they can easily be reinforced to double that number from the reserve, when desirable.

From the foregoing, I do not wish to be understood as advocating the maintenance of our whole army in such an organisation; nor does the consideration of how far we should keep the framework of it on foot lie within the scope of this paper. I would merely suggest for those who hold views on the subject, the unique advantage we possess in our insular position—enabling us at the first breath of war to fill up our divisions and corps unmolested, and embark them complete for any theatre of operations beyond the sea. So that probably we do not require to live in so completely organised a condition as our neighbours.

Now, although there seems to be in the present day the same fascination exercised by German military ideas as there was a few years ago by French, I think we should shew ourselves to be less wise than our neighbours did we attempt to make ours, as it were, a thoroughly Germanized army. Their organisation we may concede to be the best yet discovered for a large continental power raised by the sword, living by the sword, and may be some day to perish by the sword—a power that has assumed such a position in Europe that its existence depends upon its ability to cope, single-handed and at short notice, with the vast power of Russia, or with such an upheaval of the French nation as the close of last century witnessed, or with any attempt at disruption amongst her present constituent atoms. Now, this in no way reflects the situation of England; and it would be a bad day for us, should admirers of the German military system curse this free country with so vast a military organisation—an organisation admirable from a strictly military point of view, but lamentable from every other.

Believing that artillery forms one branch of science, complete in itself, I conceive that it would be a blunder at the outset to divide the officers, as has been suggested in the "Times" and "Pall Mall Gazette," into field and garrison; although the Germans have, I believe, lately done so. In a pamphlet translated from the German by Capt. Clarke, and issued from this Institution, this idea was discussed; but I failed to perceive any sufficient reason in favor of such a view, the reasons against such a course

seeming to me conspicuous from their omission; and I would apply to it the same criticism that the writer does in his introduction to every rival scheme—for there seem to have been many—"The writing, like almost all the essays on the same question, suffers from a fault which detracts considerably from its value. The first part, which may be called negative, and which lays bare the disadvantages of an organisation, is clear and convincing; *not so the second part, which contains proposals for its improvement.*" I have the greatest respect and reverence for German philosophic thought, and readily acknowledge our obligation to German thinkers; but this pamphlet presents to my mind no mark of any such philosophy, but rather that the officers of the Prussian artillery, having been for a long time past lightly regarded by their brethren of the other arms (and notably so after the campaign of 1866), are now fired with the same desire that animates us—to advance their branch of the service. In the last war it was brought vividly home to them what striking results could be achieved in the field by an intelligent use of artillery, and the more influential and enthusiastic portion of the officers have succeeded in cutting the field artillery adrift from what they felt to be a clog to their advancement—namely, the garrison artillery. You may smile, Gentlemen, at the audacity of your lecturer's differing from German military authority, but I humbly submit such a measure to have been unphilosophical, and calculated to hinder the advance of artillery science amongst them. I apprehend that to confine one portion of your men of artillery science solely to the service of field artillery and its tactics, and the other to that of siege or garrison artillery, even after a hard and fast line has been drawn where the service of guns of position ends and that of the lighter siege guns begins, is about as unphilosophical as to attempt to divide the science of astronomy or of geology into departments. What should we say of an astronomer who proposed to confine his observations to the moon?—he might be a lunatic, but I deny that he would deserve to be called an astronomer; or of the geologist who would investigate fossils without any reference to the strata and conditions amidst which they were found? If we aspire to be scientific artillerists, we must be prepared to grapple with our subject in all its phases. I feel sure that the experience of many here to-day will bear testimony to the benefit they have personally derived from a varied service in field and garrison artillery. I have myself seen notable instances in which officers whose names are more especially connected with the horse and field artillery, have shewn themselves second to none when serving with siege artillery, and *vice versâ*. I deprecate any such separation—for the sake of the field artillery, to whom such a change means less scientific knowledge, excluded as they would be from the chief part of the courses at the School of Gunnery and the Royal Arsenal; for the sake of the garrison artillery, as they would tend to become rather pedants than smart and enterprising soldiers; and for the sake of the artillery as a whole, inasmuch as pure science being restricted to one section only, the general scientific average would be reduced. Instead of, as we have now, more than 1000 officers of every grade and phase of intellect acting and re-acting upon each other for the attainment of one grand object, we should be divided into two bodies separated by jealous rivalry. It is a grand object to place England in advance of the other nations of Europe,

as the representative of artillery science. Is it worth so much to attain the same position for the field artillery alone, or for the garrison artillery alone?

The separation of the German artillery seems to have been necessitated by a partial and narrow-minded regimental administration, which the officers were powerless to reform; not from any inherent defect in the organisation, if honestly administered. The garrison artillery seems to have been habitually starved, under-officered, and neglected for the sake of the field artillery. The principal, and I think only argument of any weight in favor of a partition of the regiment, seems to lie in such difference as exists in the nature of the duties of field and garrison artillery. These have been so fully discussed in the German pamphlet before alluded to, that I will assume them to be fresh in the minds of those present. It will easily be understood, then, how, under such regimental administration as the writer describes, these differences could be made productive of evils past endurance. Whilst conceding that the theory of our system might admit of such abuses, I think we must in common justice own that with us every facility has been afforded to officers to make their own way into that branch of the artillery for which they have felt most inclination; and besides this, great opportunities have remained in the hands of successive D.-A.-Generals, which have on the whole been wisely used, for still further carrying out the idea of transferring officers to that branch of the regiment for which they have evinced greater fitness. It is a delicate question whether such principle of selection might not be still further carried out with advantage. Still, it would be uncandid not to admit that there lies in all this a warning for those amongst ourselves who are desirous of maintaining the unity of the Royal Artillery. It is impossible that the regiment can bear the strain of war, unless there exists the same determination to maintain the efficiency of the garrison artillery as of the field. Garrison artillery cannot usefully exist under-officered, disregarded—I may say, uncherished. I do not care to discuss whether in the past one branch of our artillery service has been cherished at the expense of another. It is impossible for superficial observers to appreciate the difficulties which military administrators have to encounter to keep the machine in motion at all. In seasons when the House of Commons is suffering from a paroxysm of economy, some part of it must suffer, and of course it will be that which is for the moment in least request. We have, however, now good reason to hope that the hour has struck when it will be possible to maintain the efficiency of every branch alike. I would venture to offer, then, as a postulate, that artillery cannot efficiently exist as one corps unless the requirements of each branch of it are equally regarded; and in doing so, I am sanguine enough to believe that I am not asking you to accept what is impracticable. There is another consideration which I find untouched in this German pamphlet. An officer is liable to that common weakness of humanity—growing older, involving very often change of ideas, change of predilections and favourite pursuits. I apprehend that many officers would not care to have their horizon limited even to service in the horse artillery; though I dare say a good many young men think they would be contented. However that may be, can we do otherwise than feel assured that the more a man's horizon is limited, the less likely

he is to hold those liberal views which scientific pursuits especially demand? If it be conceded that no necessity exists for every artillery officer being a philosopher, the truth still remains that a prejudiced man, whose mind runs in one groove, and who regards the business of life, as it were, through a single eye-glass, is an anachronism in a corps claiming to be considered "scientific."

It is, I believe, by no means inconsistent with what I have just maintained for the framework of the regiment, to affirm that the principle which has been adopted for some years past of dividing the men and horses into horse, field, and garrison is a true one. A soldier enters the service in most cases without any preparation or education worthy of the name. It is therefore impossible during his 12 years' service to teach him to perform intelligently the special duties pertaining to each separate branch. The widest gulf imaginable separates him from his officer—namely, education. Therefore, the restriction of an uneducated soldier, who only serves for 12 years, to one branch, constitutes no argument for applying the same rule to his educated officer, to whom the service is the business, and artillery science the study of a life time.

In the "Studies on the Leading of Troops," translated from the German by Col. Ouvry, C.B., the considerations upon which the German artillery organisation is based are well stated:—"In the situations in war on a large scale, individual batteries cannot manœuvre of their own accord, as frequently happens in small detachment exercises. Where 12,000 infantry are striving to attain one object, the artillery distributed to them should not seek to act on its own account, but on the contrary it should contribute to the attainment of that object with its united power, which is possible only when the batteries do not act independently, but obey one will. In war on a large scale, employing the batteries in a mass is the rule; their isolated employment the exception. This principle must be rather the more maintained, inasmuch as the actuality frequently renders the exception necessary." The last sentence would seem to point to the possible danger of making the tactical unit too large.

In one of the best papers on artillery which have appeared in the "Times" lately, dated Berlin, August 1872, it may be gathered that the Prussian field artillery, having been divorced from the garrison artillery, has been organised into regiments, two of which form a brigade—the artillery complement of a *corps d'armée*—under a general officer. One of these two regiments, consisting of eight field batteries, is called the Divisional Regiment, being divided on service between the two army Divisions in divisions of four batteries each; the other is called the Corps Artillery Regiment, and consists of five field batteries and three horse artillery batteries, which latter are divided on service between the reserve and cavalry division. Besides the artillery general and his staff for the whole, there is a colonel for each of these regiments, and a major for each division of four batteries. The writer goes on to say:—"As far as may be, these four batteries are kept together, though on actual service it frequently becomes necessary to separate them."

Now, I argue that if this paragraph be true of the artillery of the Prussian army—one of the largest in the world, an army having no obligation except that of constant preparation for war on a colossal

scale—* *a fortiori*, it would be unsuitable for our comparatively small army, with the constant obligation of being prepared for war on a small scale under the most variable circumstances. To inflict upon our army such an artillery organisation, would produce the same results, probably, as would ensue from arming a dwarf with the club of a Hercules, forgetting the lesson learned by us in the nursery that dwarfs can only cope successfully with giants by superior ingenuity and skilfulness.

I propose that the men, horses, and *matériel* should be divided into three groups or divisions, with the head-quarters of each stationed permanently in England. The *spécialité* of field artillery seems to call for a further sub-organisation. That the present brigades of artillery are unsuited to active service, seems to be admitted by authority; as in a foot note to page 13 "Artillery Equipment Regulations," we read:—"For administrative purposes, the entire regiment is divided into brigades, containing seven or eight batteries each. A complete brigade would never be sent into the field, unless it happened to contain the right proportion of men for the ordnance employed." Now, from the wording of this, the brigade organisation does not take its stand as being purely and simply administrative, or purely and simply tactical; that unfortunate word "unless" seems to deprive it of any definite standing ground. The present brigade is therefore evidently not of much value as a unit of any kind. We may gather from Captain May's criticism of the Prussian artillery tactics of 1866, and their performances since, that, setting all due value upon the independence lately conceded to single batteries in our service, the battery is too small a tactical unit wherewith to ensure concentration of artillery fire—which I take to be as absolute a necessity as concentration of musketry fire. At the same time, we must beware of an organisation which would bind more batteries together than would be suitable to the daily requirements of the English army; (I say English, for the reasons stated at the beginning of my lecture). I therefore propose as a tactical unit for field artillery, the complement laid down by regulation for a division of the army—viz. 2 batteries; and to form them into a permanent brigade under a lieutenant-colonel. I do not think that this will by any means be detrimental to the greatest freedom of a battery acting independently when occasion requires it. In nearly any country you could ensure concentrating within reasonable distance two batteries of six guns; for although you will doubtless acquit me of such a confusion of ideas as to consider concentration of fire and concentration of guns to be identical, yet, in order to direct a concentration of fire amidst the turmoil of a battle-field, there is a natural limit beyond which extension would be inconvenient. The corps or reserve artillery, under the command of a colonel, would be made up of so many of these brigades as might be proportionate to the strength of the *corps d'armée* and the physical character of the theatre of operations; and it would doubtless prove easier for the colonel to gather up his guns for a grand *coup* formed into these brigades than by single batteries unaccustomed to work together. The artillery of a *corps d'armée* would thus be organised:—One brigade of artillery for each division, under a lieut.-colonel, whose

* And it is corroborated by the concluding words in the passage which I quoted from Col. Ouvry's translation.

power of concentration would extend to 12 guns; the corps artillery under a colonel, with power of concentrating all the brigades in his corps or reserve. The major-general commanding all the artillery in the *corps d'armée*, under the orders of the general in command, would be able to concentrate all the divisional artillery, reinforce it from the reserve, or, in short, make such dispositions as might appear desirable. The only rule to be observed in attaching or detaching artillery would be, that so far as practicable a brigade should be kept inviolate—that is, work by two batteries instead of by single ones. If this organisation be well suited for active service, which is the prime consideration, I think it can be shewn that it is well suited to the every-day requirements of India, where half our field and horse artillery is permanently stationed, and where it is located with greater reference to military requirements than is necessary at home. You will observe that two batteries can always be contained within the territorial limits of a military division; also, that the reserve artillery can always be stationed, in the brigades I have recommended, at such points as the commander of the force may direct—such as Kirkee, &c. In some divisions of the army there are only two batteries, and these located at different stations. In such cases, the lieut.-colonel would be at the divisional head-quarters with his general. In others, where there are more batteries, a colonel would be stationed with the general in command of the whole, and the lieut.-colonels would join their brigades where concentrated; or if detached by single batteries, as a regiment is sometimes by wings or squadrons, then with such battery as the colonel of the district might direct.

The same principle seems to be of easy application at home, by observing that batteries should be apportioned to military districts by even instead of by uneven numbers. The objection that presents itself to my mind against any larger unit than that of two batteries is, that except in actual war on a large scale you could not canton artillery, either at home or in India, without violating it; which involves all the inconveniences of the present system. On the other hand, by the adoption of a fighting unit which is equally convenient for our army in peace, we obtain for the artillery all the advantages of the regimental system. The advantage to a general is manifest, of receiving into his division his complement of artillery in one homogeneous brigade, as compared with receiving such complement made up of batteries strange, perhaps, to each other, and to the lieut.-colonel who might be appointed to their command. Sir A. Frazer expressed his opinion very strongly upon this head after the Waterloo campaign. I think, too, it is only by such an organisation that the field artillery can enter into that intimate association with the other arms which is so essential to the general development of tactical knowledge. Is there not something unworkmanlike in the way single batteries move from one military district to another, describing an eccentric orbit round a brigade head-quarters, stationed somewhere for no very obvious reason, and unrecognisable by the general officers under whom the batteries are serving? I fear that to any but artillerymen our present system is a kind of Asian mystery, and it is a matter of doubt whether the oldest army staff officers thoroughly fathom it. Perhaps no step could be more conducive to the feeling in the minds of general officers that the

artillery is as really under their individual command, both in barracks and in the field, as the other arms, than by giving it a simple organisation that would not require special study to comprehend it thoroughly. The day has gone by when general officers can be content to direct the artillery to conform to the movement of the other troops. There are phases in a battle when upon the action of the artillery all may depend; and what general worthy of the name will be content to leave the determination of that moment to the judgment of the most gifted subordinate? Ought he not, therefore, to be as familiar with the capabilities of his artillery as with those of his infantry? The necessity, therefore, of giving the artillery a simple and intelligible organisation is urgent, and the more akin to that of the other arms the better.

To proceed to the consideration of garrison artillery: I propose no intermediate organisation between that of the division and battery. Garrison or siege artillery is, in the strictest military sense, reserve. As its duty is to provide for the garrison of a small fort or large fortress, or to furnish a train for a siege like that of Sebastopol, or to meet the necessities of our widely scattered colonies and possessions, I hold that no fagotting together of batteries would be free from the disadvantages of our present system. The garrison artillery should constitute one reserve division, from which batteries could be detached singly, or in numbers, as required for the special service contemplated. The lieut.-colonels of garrison brigades, besides being detached when required for service with the batteries, might be appointed for definite periods to districts and sub-districts, whereby they would become identified with the armaments in their charge.

In what I have said, I have only ventured to indicate such an organisation as would, in my humble opinion, afford a tactical basis suitable to the Royal Artillery, and have purposely omitted all details—such as promotion of N.C. officers, returns, correspondence, &c.—as I think the nature of the proposal is sufficiently suggestive of the *modus operandi* in these subordinate particulars. At any rate, were the principle that I have suggested adopted, these details would be easily worked out.

In studying the battle-fields of modern times, one cannot help being struck with the subordinate part played by the artillery of the English, as compared with that of continental armies. We have, indeed, been on the whole successful, but at such an expenditure of life as to give rise to the savage remark that "John Bull estimates a victory by the extent of the butcher's bill;" and it seems probable that had there existed a more just appreciation of the capabilities of artillery, our victories from Waterloo to the present day would have been none the less decisive, whilst the sacrifice of life would have been less.

Within the last few years, opinion has corrected itself, and in future decisive tactical results will be looked for at our hands—and in vain, unless the preparation for them is meanwhile laid in a real, sound, and intelligent organisation.

A short discussion followed, and the proceedings then terminated with a vote of thanks to Major Geary for his able lecture.

THE GERMAN ARTILLERY IN 1870–71.

TRANSLATED FROM THE FRENCH BY

CAPTAIN HIME, R.A.

Combat of Wissembourg,

4th August, 1870.

90 guns: 42 of 9 centimetres, and 48 of 8 centimetres.

Guns of 9 c.			*Guns of 8 c.*		
Common shell.	Shrapnel.	Case.	Common shell.	Shrapnel.	Case.
631	19	0	749	0	0

Total: 1380 common shell, and 19 shrapnel.
No. of rounds per gun, 15·5.
Loss: 3 artillery officers, 20 artillerymen, and 49 artillery horses.

Battle of Wörth,

6th August, 1870.

231 guns: 90 of 9 c., and 141 of 8 c.

Guns of 9 c.			*Guns of 8 c.*		
Common shell.	Shrapnel.	Case.	Common shell.	Shrapnel.	Case.
3028	12	0	6748	0	64

Total: 9776 common shell, 12 shrapnel, and 64 case.
No. of rounds per gun, 42·6.
Loss: 12 officers, 137 men, and 300 horses.

Battle of Spicheren,

6th August, 1870.

78 guns: 30 of 9 c., and 48 of 8 c.

Guns of 9 c.			*Guns of 8 c.*		
Common shell.	Shrapnel.	Case.	Common shell.	Shrapnel.	Case.
1045	0	0	1329	0	0

Total: 2374 common shell.
No. of rounds per gun, 30·4.
Loss: 7 officers, 77 men, and 105 horses.

Battle of Borny,

14th August, 1870.

137 guns: 55 of 9 c., and 82 of 8 c.

Guns of 9 *c.*			*Guns of* 8 *c.*		
Common shell.	Shrapnel.	Case.	Common shell.	Shrapnel.	Case.
781	0	0	2068	0	6

Total: 2849 common shell, and 6 case.
No. of rounds per gun, 20·7.
Loss: 12 officers, 137 men, and 159 horses.

Battle of Mars-la-Tour,

16th August, 1870.

222 guns: 90 of 9 c., and 132 of 8 c.

Guns of 9 *c.*			*Guns of* 8 *c.*		
Common shell.	Shrapnel.	Case.	Common shell.	Shrapnel.	Case.
6915	0	0	13,296	0	18

Total: 20,841 common shell, and 18 case.
No. of rounds per gun, 94.
Loss: 44 officers, 682 men, and 993 horses.

Battle of Gravelotte,

18th August, 1870.

616 guns: 256 of 9 c., and 360 of 8 c.

Guns of 9 *c.*			*Guns of* 8 *c.*		
Common shell.	Shrapnel.	Case.	Common shell.	Shrapnel.	Case.
12,191	44	4	22,437	152	16

Total: 34,628 common shell, 196 shrapnel, and 20 canister.
No. of rounds per gun, 56·5.
Loss: 85 officers, 834 men, and 1477 horses; 2 guns of 9 c., and 2 wagons lost; 2 limbers blown up; 2 guns unserviceable.

Battle of Beaumont,

30th August, 1870.

222 guns: 108 of 9 c., and 114 of 8 c.

Guns of 9 *c.*			*Guns of* 8 *c.*		
Common shell.	Shrapnel.	Case.	Common shell.	Shrapnel.	Case.
2812	52	0	3750	49	0

Total: 6562 common shell, and 101 shrapnel.
No. of rounds per gun, 30.
Loss: 12 officers, 140 men, and 174 horses.

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Battle of Noisseville.

31st August and 1st September, 1870.

180 Guns: 78 of 9 c., and 102 of 8 c.

Guns of 9 *c.*			*Guns of* 8 *c.*		
Common shell.	Shrapnel.	Case.	Common shell.	Shrapnel.	Case.
4406	0	15	6048	0	13

Total: 10,668 common shell, and 28 case.
No. of rounds per gun, 59·5.
Loss: 13 officers, 147 men, and 191 horses; 1 gun-carriage dismounted.

Battle of Sedan,

1st September, 1870.

599 guns: 294 of 9 c., and 305 of 8 c.

Guns of 9 *c.*			*Guns of* 8 *c.*		
Common shell.	Shrapnel.	Case.	Common shell.	Shrapnel.	Case.
15,298	625	50	16,656	649	6

Total: 31,954 common shell, 1274 shrapnel, and 56 case.
No. of rounds per gun, 55·8.
Loss: 30 officers, 430 men, and 800 horses; 1 steel gun of 8 c. burst.

Combat of Coulmiers,

9th November, 1870.

110 guns: 60 of 9 c., 46 of 8 c., and 4 Bavarian mitrailleurs.

Guns of 9 *c.*			*Guns of* 8 *c.*		
Common shell.	Shrapnel.	Case.	Common shell.	Shrapnel.	Case.
3284	248	2	3632	0	2

Total: 6916 common shell, 248 shrapnel, and 4 case.
No. of rounds per gun, 67·6.
Loss: 5 officers, 62 men, and 104 horses; 2 gun-carriages and 1 baggage wagon dismounted; 2 guns of reserve, 4 spare gun-carriages, 12 ammunition wagons, and 4 other carriages lost.

Battle of Amiens,

27th November, 1870.

138 guns: 54 of 9 c., and 84 of 8 c.

Guns of 9 *c.*			*Guns of* 8 *c.*		
Common shell.	Shrapnel.	Case.	Common shell.	Shrapnel.	Case.
1791	0	0	4278	0	0

Total: 6069 common shell.
No. of rounds per gun, 44.
Loss: 11 officers, 162 men, and 201 horses; 1 limber-box blown up.

Battle of Beaune la Rolande.

28th November, 1870.

96 guns: 30 of 9 c., and 66 of 8 c.

Guns of 9 *c.*			*Guns of* 8 *c.*		
Common shell.	Shrapnel.	Case.	Common shell.	Shrapnel.	Case.
837	0	5	1979	0	0

Total: 2816 common shell, and 5 case.
No. of rounds per gun, 29·4.
Loss: 2 officers, 69 men, and 157 horses; 1 gun lost.

Battles of Villiers and Champigny.

30th November and 2nd December, 1870.

150 guns: 54 of 9 c., and 96 of 8 c.

Guns of 9 *c.*			*Guns of* 8 *c.*		
Common shell.	Shrapnel.	Case.	Common shell.	Shrapnel.	Case.
2850	54	0	5841	115	8

Total: 8691 common shell, 169 shrapnel, and 8 case.
No. of rounds per gun, 59·1.
Loss: 11 officers, 194 men, and 286 horses; 1 limber and 1 wagon blown up, and 1 gun dismounted.

Battle of Orleans,

2nd, 3rd, and 4th December, 1870.

388 guns: 6 of 12 c., 168 of 9 c., and 214 of 8 c.

Guns of 12 *c.*			*Guns of* 9 *c.*			*Guns of* 8 *c.*		
Com. shell.	Shrap.	Case.	Com. shell.	Shrap.	Case.	Com. shell.	Shrap.	Case.
470	0	0	12,941	758	19	17,570	0	40

Total: 30,581 common shell, 752 shrapnel, and 59 case.
No. of rounds per gun, 80·9.
Loss: 33 officers, 389 men, and 622 horses; 2 gun-carriages dismounted.

Battles of Beaugency and Cravant,

7th, 8th, 9th, & 10th December, 1870.

293 guns: 5 of 12 c., 132 of 9 c., and 156 of 8 c.

Guns of 12 *c.*			*Guns of* 9 *c.*			*Guns of* 8 *c.*		
Com. shell.	Shrap.	Case.	Com. shell.	Shrap.	Case.	Com. shell.	Shrap.	Case.
172	0	0	13,342	690	0	11,544	0	7

Total: 25,058 common shell, 690 shrapnel, and 7 case.
No. of rounds per gun, 89·6.
Loss: 25 officers, 280 men, and 409 horses; 1 gun and 1 gun-carriage unserviceable.

Combat of Bapaume,

3rd January, 1871.

72 guns: 30 of 9 c., and 42 of 8 c.

Guns of 9 c.			*Guns of 8 c.*		
Common shell.	Shrapnel.	Case.	Common shell.	Shrapnel.	Case.
778	0	0	1423	0	0

Total: 2201 common shell.
No. of rounds per gun, 30·6.
Loss: 3 officers, 34 men, and 97 horses.

Battle of le Mans,

11th & 12th January, 1871.

234 guns: 102 of 9 c., and 132 of 8 c.

Guns of 9 c.			*Guns of 8 c.*		
Common shell.	Shrapnel.	Case.	Common shell.	Shrapnel.	Case.
2531	0	0	3565	0	1

Total: 6096 common shell, and 1 case.
No. of rounds per gun, 26.
Loss: 14 officers, 110 men, and 145 horses.

Battle of S. Quentin,

19th January, 1871.

161 guns: 66 of 9 c., and 95 of 8 c.

Guns of 9 c.			*Guns of 8 c.*		
Common shell.	Shrapnel.	Case.	Common shell.	Shrapnel.	Case.
2964	0	2	4210	106	0

Total: 7174 common shell, 106 shrapnel, and 2 canister.
No. of rounds per gun, 45·2.
Loss: 12 officers, 166 men, and 180 horses.

I have taken the foregoing figures from the "Revue Militaire de l'Etranger," of the 16th and 21st November, 1872. The "Revue" translated them from the German of the "Militair-Wochenblatt," to which they had been communicated by two German officers, who compiled them from reports furnished them by the kindness of the War Ministers of the different German States. Owing to the loss of the reports of a few German batteries, the figures are not absolutely correct; but they are a close approximation to the truth. They may be found in the "Beiheft zum Militair-Wochenblatt, 1872, Zehntes Heft," p. 319.

Under the term "common shell," I have included the "obus ordinaire" and the "obus incendiaire." Very few of the latter were used.

The use of canister is evidently becoming rarer and rarer. It must be remembered, however, that during the war of 1870–71 the Prussians acted almost always on the offensive, the French on the defensive. It is probable, therefore, that a larger amount of canister was used by the French than by the Germans.

It is startling to find that, in the majority of cases, the loss in horses was double the loss in men. It is probable that the great losses in horses experienced by the Prussians, was to some extent due to their offensive tactics. At Gravelotte, a horse artillery battery of the 9th Corps lost 120 horses—a loss which rivals that of "G" Troop, R.H.A. at Waterloo. (See the "Militair-Wochenblatt" of the 30th Nov. 1872, p. 912.)

These statistics unfortunately give us no clue to the relative proportion of common and shrapnel shell required in modern war. The Prussians had no shrapnel at the outbreak of the war, and were compelled to use common shell throughout the whole of it. The shrapnel used belonged to the Saxons, Bavarians, Hessians, and Magdeburgers.

Too much reliance must not be placed on the number of rounds fired per gun; since in many instances the number of rounds fired was much less, and in others considerably more, than the average. For instance, the artillery of the 12th Corps at Gravelotte fired 151 rounds per gun; while the artillery of the Guard, at the same battle, fired 100 rounds per gun. It is certain that other batteries fired as much as 200 rounds per gun. At Artenay, 2nd Dec. 1870, the 36 guns of the 22nd Division fired 5000 rounds in 5 hours; giving an average of 139 rounds per gun, and 1 shot per gun every 2 minutes. ("Militair-Wochenblatt," 30th Oct. 1870, p. 826).

The guns of 9 and 8 centimetres are respectively the 6 and 4-pr. German field guns.

H. W. L. H.

GLASGOW,
January, 1873.

THE CALIBRE OF FIELD GUNS.

BY

W. H. NOBLE, M.A.,

CAPTAIN R.A.

"As to the general question of large bore and small bore, light guns or heavier guns, he supposed it was a point upon which they must agree to differ."*

IN common, doubtless, with many of my brother officers, I have read with much interest a paper in the present volume,† in which the author has given a very lucid explanation of the technical term "flat trajectory."

It is not my intention in the present paper to enter into any discussion on theoretical points that are beyond dispute; but as the author appears to have—doubtless inadvertently—fallen into several practical errors, which hitherto have remained unquestioned or unnoticed, it seems desirable that some one—even at this late period—should draw attention to the defects in an otherwise able paper.

In the discussion which followed the reading of the paper, it is perhaps unfortunate that no one seemed willing to take up the other side of the question, or competent to give information which probably would have considerably changed the aspect in which the subject, from first to last, appears to have been viewed.

It is now, perhaps, too late to enter upon a discussion in a controversial sense; I shall therefore merely take exception, in a spirit of fair criticism, to various statements which the author has made in the paper under consideration, and which it is desirable should not remain uncontradicted in the pages of the Royal Artillery Institution's "Proceedings."

From the general tone of "Flat Trajectories," it may be gathered that the author is not satisfied with the method pursued in carrying out certain experiments with two 12-cwt. field guns, of the respective calibres of 3·6 in. and 3·3 in.

* Extract from remarks made by Major-Gen. Lefroy, C.B., during a discussion in the Theatre of the Royal Artillery Institution.—"Proceedings R.A. Institution," Vol. VII., p. 292.

† "Flat Trajectories; what are they?"—"Proceedings R.A. Institution," Vol. VIII., p. 74.

That he considers erroneous conclusions have been drawn from these experiments, the result being the recommendation and adoption of the less powerful of the above two guns.

That the apparent results, as regards range, &c., given by one of the two guns (3·6-in.) do not agree with certain theoretical hypotheses, and can therefore only be accounted for on the assumption that the recoil of this particular gun was checked, thus causing it to throw higher than the other; and that the employment of a different description of powder—such, for instance, as L.G., of which we have a large store—might possibly have given better results in the rejected gun, and might thus have led to a reversal of the final award.

I trust, however, that when the subject is considered in *all* its bearings, it will appear—that the method of experimenting followed in this instance was a fair and adequate means of determining the relative shooting powers of the respective guns at practical artillery ranges.

That, all things considered, no other decision than the one arrived at, could have been come to.

That the observed ranges must be accepted as the true ranges, and that relatively they are absolutely independent of, and uninfluenced by, the recoil.

Lastly, that the employment of a different powder—such as L.G.—so far from being attended with beneficial results in the 3·3-in. gun, would in all probability have had the reverse effect.

As the points first raised, to some extent, depend upon the conclusions arrived at with regard to those last stated, it will be convenient to discuss the several questions at issue in the inverse order.

To commence, therefore, with the last—

The following paragraph appears at page 82.*

"One thing the experiment does show—that 3 lbs. of R.L.G. powder are not so effectively consumed in a 3·3-in. as in a 3·6-in. bore of the *same length;* but which is of the most importance—burning the powder, or destroying the enemy? Besides, it has not been shown that L.G. powder, of which we have a large store, would not have given a better result as regards muzzle velocity in comparison with the 3·6-in., than the R.L.G. has done. A charge of 3 lbs. of L.G. powder has been fired in the 3·6-in. gun, and has given a muzzle velocity of only 1283 f.s. Service L.G. powder has a smaller grain than service R.L.G., and therefore might burn quicker—although it is unsafe to predict, with our present knowledge, what powder will do."

I confess I do not clearly understand the argument in the first part of this paragraph. It seems to infer that the powder might possibly have been more thoroughly consumed in the 3·3-in. gun had the bore been longer. But would not this have been handicapping the 3·6-in. gun? Might not the consumption of the charge in the latter gun have also been benefited by an increase in length of bore? Was it not

* "Proceedings R.A. Institution," Vol. VIII.

much the fairest plan that both guns should have the same length of bore, and that the only variable should be the calibre? We must bear in mind that the length of a field gun, in a great measure, depends upon convenience in travelling and working. There is a certain length which it is not advisable to exceed.

The fact of a field gun being 3·6 or 3·3 inches in calibre cannot influence the practical conditions which govern the length of the gun. The inference, therefore, that the latter gun would be improved by an increase of length, cannot be accepted as an argument in favour of the smaller bore.

The following table gives the lengths of the rifled field guns in use in the principal armies of Europe:—

TABLE I.

Nation.	Total length of gun.	
	Light field piece, corresponding to British 9-pr.	Heavy field piece, corresponding to British 16-pr.
	ins.	ins.
England	72·00	78·00
Austria	54·45	66·38
France	62·99	79·21
Prussia	74·00	78·00
Italy	64·17	85·20*
Russia	70·00	73·00
Spain	76·16	81·44

With regard to the latter part of the paragraph, the chain of reasoning appears to be that because 3 lb. of L.G. powder has given a muzzle velocity of only 1283 ft., as compared with 1358 ft. given by R.L.G., in a 3·6-in. gun, therefore L.G. powder would have given a better comparative result in the two guns, as regards muzzle velocity, than R.L.G.

This argument, of course, mainly rests upon the figures 1283. If these figures correctly represent the normal muzzle velocity with 3 lb. of L.G. in the 3·6-in. calibre, the argument is legitimate; if they do not do so, the argument is groundless.

To enable my readers to judge for themselves, I shall here quote† the official tables which give the results of velocity trials with R.L.G. in the 3·3 and 3·6-in. guns, as well as those of subsequent trials of L.G. in the 3·6-in. gun, and from which the author of "Flat Trajectories" must have derived his information.

* A 24-pr. of 14 cwt.

† "Extracts from the Quarterly Reports of Proceedings of the Department of Director of Artillery," Vol. IX., p. 143.

Table II.

"Captain W. H. Noble, R.A., 26. 7. 71, submits, for record, the following abstract, giving the results of experiments, carried out at Shoeburyness, to determine the muzzle velocity of common shells fired with charges of 3 lbs. from the 16-pr. wrought-iron M.L.R. guns of 3·6-in. and 3·3-in. calibre. The 3·6-in. gun was fitted with a removable centre vent, and advantage was taken of this circumstance to determine the loss of velocity, in this calibre, due to placing the vent at the end of the bore. The vent strikes the cartridge at 0·6 in. from the rear end of bore. With the forward vent the cartridge was struck at 4·4 ins. from the rear. The latter vent, however, is unsuitable for low charges, and facilitates the deposit of half consumed cartridge in the bore.

"It appears that the muzzle velocity with the 3·6-in. gun is 51 ft. in excess of that with the 3·3-in. gun. Both guns were fired under the same circumstances.

Brand of powder, R.L.G., W.A., lot 1637.

Gun, and date of experiment.	No. of rounds fired.	Charge.	Length and diameter of cartridge.	Projectile. Nature, mean weight, length, and diameter.	Position of vent.	Observed velocities at 50 yds.					Mean observed velocity.	Calculated mean initial velocity.	Remarks.
		lbs.	ins.			ft.	ft.	ft.	ft.	ft.	ft.	ft.	
3·6-in. Expl. No. 385. 8. 6. 71.	2	3	11·8 × 2·9*	com. shell, 16 lbs. 10 ins. 3·54 "	rear.	1328	1340	—	—	—	1334	1357	
	5	3	10·3 × 3·2	do.	do.	1334	1332	1328	1343	1340	1335	1358	
	6†	3	do.	do.	forward.	1381	1377	1377	1370	1370	1375	1397	
3·3-in. Expl. No. 390.	5	3	11·8 × 2·9	com. shell, 16 lbs. 11·3 ins. 3·24 "	rear.	1281	1289	1296	1294	1269	1286	1307	

Table III.

"Captain W. H. Noble, R.A., 26. 8. 71, submits, for record, the following abstract, giving the results of experiments to ascertain the velocity and regularity of velocity of common shells fired from the 16-pr. (3·6-in.) M.L.R. gun of 12 cwt.

Gun, and date of experiment.	No. of rounds.	Charge.	Length and diameter of cartridge.	Projectile. Nature, mean weight, length, and diameter.	Observed velocities at 50 yds.					Mean observed velocity.	Mean difference of velocity.	Calculated mean initial velocity.
		lbs.	ins.		ft.	ft.	ft.	ft.	ft.	ft.	ft.	ft.
16-pr. M.L.R. Expl. No. 385, 25. 8. 71.	10	3 L.G. Curtis & Harvey, 2. 6. 57, lot 97.	11 × 3·2	com. shell, 16lbs., 10 ins. 3·54 "	1358 1300	1328 1345	1325 1345	1323 1358	1323 1351	1336	15·8	1359
	10	3 L.G. from Examination 1870.	"	"	1260 1270	1274 1251	1276 1218	1264 1254	1283 1269	1262	12·9	1283
	10	3 R.L.G. 15. 9. 70, lot 1637.	10·75 × 3·2	"	1314 1322	1363 1347	1309 1347	1309 1338	1344 1328	1332	15·7	1355

"It appears that there is a considerable loss of velocity with L.G. powder of 'Examination 1870.' The Supt. R.G.P.F. states that this powder is from broken up cartridges.

"The velocities are on the whole irregular.

"The practice was carried out under the same conditions as that reported on *preceding Minute*, with the exception that in the present case the cartridges were of serge instead of silk cloth. The ranges at 2° corresponded in a marked manner with the velocities."

* Cartridge for 3·3-in. gun used by mistake. † 1 miss.

It appears from the last table that the figures 1283 belong to an inferior description of powder, marked "Examination 1870," and that *good* L.G. powder gave a velocity somewhat *exceeding* that of R.L.G.

The author of "Flat Trajectories" would scarcely have selected these figures had he been aware that their publication was the cause of a lengthened correspondence between the Departments concerned, in the course of which the Superintendent Royal Gunpowder Factories stated "that the L.G. powder issued to Shoeburyness (marked 'from examination 1870'), cannot be said to represent fairly the present service stock of L.G. powder, which has been brought into general use for M.L.R. field guns (*see* § 2087 *List of Changes*), as it was obtained from broken up cartridges and powders of unknown dates and makers;" and the Secretary of the Experimental Branch at Woolwich submitted "that steps should be at once taken—

"1. To ascertain how such powder came to be issued to Shoeburyness.

"2. To replace the present store by a portion of the 2000 barrels of Pigou & Wilk's L.G. at Purfleet, which has been reserved for re-working, but not now likely to be required for that purpose.

"3. To set aside 500 barrels of L.G. at Purfleet for issue to Shoeburyness as required."*

It is manifest from the above that this particular brand of L.G. powder was of an exceptional character, that in some unaccountable manner had found its way into the Shoeburyness magazines.

The foot note to Table III. expressly points out that the powder "was from broken up cartridges." The same table gives results from an unexceptional brand of L.G. powder.

I think, therefore, had the author of "Flat Trajectories" taken 1359 instead of 1283, he would have selected figures that more correctly represent the normal velocity given by 3 lb. of L.G. powder in the 3·6-in. gun.

But, apart from figures, let us consider on theoretical grounds how the velocity would be likely to be affected by the size of grain of the powder.

Major Majendie, remarking on the influence of the size of grain, says at p. 133 of his "Treatise on Ammunition":—

"When a charge of powder is ignited, each grain in its turn becomes ignited over the whole surface, and continues burning in concentric layers until it is consumed. It is evident, therefore, that as a large grain will take a longer time to burn in this way than a small one, so, all other conditions being the same, a charge made up of large grains will take longer to burn than the same charge made up of smaller grains. But the rate at which the grains successively become ignited will also be affected by the size of the grains; and here the effect will tend in the opposite direction to that just described; for as all the interstices through which the gases pass decrease as the size of the grain decreases (all other conditions being the same), the velocity of ignition will also proportionally decrease, and in a measure counterbalance the effect

* "Proceedings, Director of Artillery," 1871, p. 309.

produced by the increased rate of burning of each grain. The direction and extent to which altering the size of the grains will affect the rapidity of action of the powder, will depend upon the conditions under which the powder is ignited—such as whether it is exploded in an open train; in small enclosed charges; in large enclosed charges; whether the charge, if large, be thick and short, or long and thin; whether it fits the bore closely; which portion of it is first ignited, &c."

Now, repeated experiments have shown that with relatively small charges, a small-grained powder gives higher velocities than one of larger grain: the effect of slow ignition is here but little felt, owing to the flame having to traverse a comparatively inconsiderable distance to complete the ignition of every grain. But in relatively large charges, *where the cartridges are necessarily long*, the reverse is the case, and the larger-grained powder gives the highest velocities.

In fact, in the latter case, the effect due to velocity of combustion in the smaller grain is more than counterbalanced by the facility given to rapidity of ignition by the larger interstices of the larger grain.

The following table, giving the mean results of an experiment lately carried out by the Committee on Explosives, forcibly illustrates this reasoning.

TABLE IV.

Showing the mean results of practice from the 9-pr. rifled M.L. gun of 8 cwt., with gunpowders differing in size of grain, and projectiles weighing 9 lb.:—

Charge, 1¼ lb.				Charge, 1½ lb.				Charge, 1¾ lb.			
Nature of powder.	Observed velocity at 110 ft.	Pressure by crusher gauge in tons per sq. in.		Nature of powder.	Observed velocity at 110 ft.	Pressure by crusher gauge in tons per sq. in.		Nature of powder.	Observed velocity at 110 ft.	Pressure by crusher gauge in tons per sq. in.	
		At centre of charge.	At base of shot.			At centre of charge.	At base of shot.			At centre of charge.	At base of shot.
	ft.				ft.				ft.		
4 to 6*	1156	6·9	5·3	4 to 6*	1263	8·5	6·4	4 to 6*	1366	10·5	8·9
4 to 8, R.L.G.	1169	7·5	3·0	4 to 8, R.L.G.	1277	9·6	7·7	4 to 8, R.L.G.	1368	10·3	7·1
6 to 8, L.G.	1185	8·4	6·1	6 to 8, L.G.	1271	8·9	6·3	6 to 8, L.G.	1336	9·5	7·6

In the experiments recorded above, the powder was all granulated from press cake of the same date of manufacture, and the only variable was the size of grain.

It is apparent that the L.G. size gives a lower velocity than the R.L.G. with large charges and comparatively long cartridges. I think, therefore, that instead of a beneficial result being obtained by the use of a relatively large charge of small-grained (L.G.) powder in a

* R.L.G., with smaller grains sifted out.

small-bore (3·3-in.) gun, and consequently with a *long* cartridge, there is every reason to expect that the reverse would be the case; and that the tendency of small-grained powder to give a lower velocity with relatively large charges, would be aggravated by the increased length of the charge—which we must remember is in both guns ignited in the rear. But this leads us to the consideration of another paragraph.

On the same page (82) the author makes the following remarks:—

"For firing reduced charges, such as are used in high-angle practice, the 3·3-in. gun would have the advantage, as the cartridge would be longer; and it would perhaps permit the vent being placed 3 ins. from the rear end of the bore, and still allow of the residue of the smallest cartridge being completely burnt up. This position of the vent would also help to give a greater muzzle velocity, as in all probability more of the powder would be burnt up."

It is, perhaps, scarcely necessary to point out that the difference of three-tenths of an inch in the diameter of the bore would have a perfectly inappreciable effect upon the dimensions of the reduced charges (4 oz.), ordinarily used in high-angle practice with this gun; and that the objections to a forward position of vent hold good equally in a 3-in., 3·3-in., 3·6-in., or any other field gun.

These guns are vented in the rear for the double object of ensuring safety while firing blank cartridges, and of igniting very reduced charges. The author of "Flat Trajectories" thinks that a forward position of vent in the 3·3-in. gun "would help to give a greater muzzle velocity, as in all probability more of the powder would be burnt up." Possibly it might.

All the heavy R.M.L. guns are vented forward, and, with R.L.G. powder, a decided increase in velocity is given by igniting the cartridge near its centre. Recent experiments, however, have indicated that this result may be reversed in the case of lower calibres.

The muzzle velocity of a 9-lb. shell, fired with $1\frac{3}{4}$ lb. R.L.G. from the 9-pr. R.M.L. of 8 cwt., is higher when the cartridge is ignited in the rear than when it is ignited near the centre.

Apart, however, from these considerations, and assuming that a forward position of vent *would* "help to give a greater muzzle velocity" in a 3·3-in. gun—would it not do the same in a 3·6-in. gun?

Table II. shows that the muzzle velocity was thus increased by 40 ft.

It would manifestly have been unfair to vent one gun forward and the other gun in rear, and all arguments for or against a change in the position of the vent appear to me to apply equally to both guns.

On the whole, therefore, I think it has been shown that (*cæteris paribus*) the relative velocities of the two guns as given in Table II. would be unaffected either by change of powder or alteration of position of vent.

Let us now examine the next question. The following table, taken from "Extracts from the Quarterly Report of Proceedings of the Department of the Director of Artillery," Vol. IX. pp. 117, 118, gives the mean results of the range and accuracy trials with the 3·3-in. and 3·6-in. guns.

Table V.

"Secretary, Woolwich, 21. 6. 71, submits the results of practice carried out at Shoeburyness, 8–9. 6. 71, for determination of range and accuracy of the undermentioned guns.

	Expl. No. 390.	Expl. No. 385.
Calibre	3·3 inches.	3·6 inches.
Length — of bore	68·4 〃	68·44 〃
Length — of rifling	55·54 〃	63·44 〃
Length — nominal	74·7 〃	74·6 〃
Rifling — grooves — number	3	3
Rifling — grooves — width	0·8 〃	0·8 〃
Rifling — grooves — depth	0·11 〃	0·11 〃
Rifling — spiral, uniform	1 in 25 cals.	1 in 30 cals.
Preponderance	3 lbs.	4 lbs.
Weight	12 cwt. 1 qr. 14 lbs.	11 cwt. 3 qrs. 4 lbs.
Vent	*Hardened copper.* 0·6 in. from end of bore.	*Steel and hardened copper.* front vent, 4·4 ins. } from end rear 〃 0·6 in. } of bore.
Common shell, with 2 rows of brass studs, 3 in a row. — diameter	3·24 ins.	3·54 ins.
— length	11·3 〃	10·0 〃
— weight, filled	16 lbs.	16 lbs.

Charge, 3 lbs. Powder, R.L.G., W.A., lot 1637.

Direction and force of wind.	Gun.	No. of rounds fired.	Corrected elevation.	Mean recoil.	Mean time of flight.	Ranges. Min.	Ranges. Max.	Ranges. Mean.	Mean difference of range.	Mean deflection. Observed.	Mean deflection. Reduced.
			° ′	ft. ins.	secs.	yds.	yds.	yds.	yds.	yds.	yds.
→ 3-5	3·3-in. Expl. No. 390.	20	2 5	18 2c	3·0 a	1007	1126	1057	21·9	5·3	0·5
→ 3	〃	20d	5 3	Checked.	6·6 b	2120	2216	2172	20·2	20·0	1·7
→ 2-3	〃	20	10 2	Checked.	12·0 b	3515	3692	3619	30·3	47·0	2·4
→ 2	3·6-in. Expl. No. 385.	20	2 5	Checked.	3·3 b	1152	1208	1187	13·2	4·1	0·8
→ 2	〃	20	5 3	Checked.	6·7	2167	2296	2228	21·0	17·5	1·2
↘ 3	〃	20	10 2	Checked.	12·1 a	3530	3640	3596	27·3	50·1	3·0

a Mean of 18. *b* Mean of 19. *c* Mean of 4. *d* One broke on graze on sands.

"Special Committee, 10. 6. 71, recommend the adoption of a 16-pr. gun of 3·6 ins. calibre, of about the same weight as the experimental gun (but not less than 12 cwt.), the same preponderance, the same system of rifling, but beginning at 10·36 ins. from bore; axis of vent 0·6 in. from end of bore."

Commenting on the figures in the above table, the author of "Flat Trajectories" (page 81), says:—

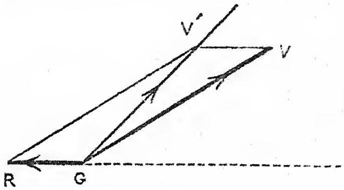
"There is a manifest discrepancy in the ranges of the 3·3-in. and 3·6-in. guns for 2° 5′ elevation (see table). By calculation it may be shown that the correct range for the 3·3-in. gun at 2° 5′ elevation would be about 1057 yds.—the same as that determined by experiment; also, the correct range for the 3·6-in. gun at the same elevation would be about 1087 yds.—*i.e.*, 100 yds. less than that determined by experiment. It can only be accounted for from the fact of the 3·3-in. gun being allowed to recoil, while the recoil of the 3·6-in. gun at the same elevation was checked."*

* "'Proceedings of Department of Director of Artillery,' Vol. IX. p. 118."

It will be observed that he quotes from the official book from which I have extracted Table V.

Again, at page 79 he makes the following comments :—

"Another point should be considered in firing guns with equal elevations: the gun which has the quickest recoil *in reality* throws higher than the other. This may be explained by a well-known mechanical



principle. Suppose *GV* to represent the rate and direction of the muzzle velocity of a shell, *GR* that of the velocity of recoil; completing the parallelogram *GRV'V*, and drawing the diagonal *GV'*, then *GV'* represents the actual rate and direction of the muzzle velocity, tending to throw the shell higher than the gun is laid. This is on the supposition that the recoil commences before the shell is clear of the muzzle. Again, if the recoil is checked, the gun and carriage have a tendency to rotate on the trail, tending also to increase the elevation. In both these cases the gun which had the liveliest recoil would actually throw the highest. A difference in the preponderance of guns, the carriages on which they are mounted, as well as the nature of the ground on which they are fired, would probably exert some influence on the actual line of fire.

"It is probably owing to some of the above reasons that the 3·6-in. gun, when laid at 5° and 10° respectively (the same as the 3·3-in. gun), threw higher than the latter, as the respective times of flight for that elevation clearly indicate (see Table V.) The recoil of the 3·3-in. gun was sensibly less than that of the 3·6-in.; and since the recoil was checked in both cases at 5° and 10° elevation, the 3·6-in. gun had a greater tendency to rotate round the trail than the 3·3-in., and consequently threw higher and ranged farther. If it had been possible to ensure both guns being fired at 5°, the 3·3-in. gun would have ranged the farthest."

It would have been more correct had the author said "in theory" instead of "in reality," as I shall presently show.

On the whole, we may gather from the above passages that the author is endeavouring to explain away the longer ranges given by the 3·6-in. gun on the suppositions—that the recoil of the 3·6-in. gun was checked at 2°, whereas that of the 3·3-in. gun was free; that the recoil with the 3·6-in. gun was quicker than that with the 3·3-in., and that this caused the former gun to throw highest; and that either a difference in the preponderance of the guns, the carriages on which they were mounted, or the nature of the ground on which they were fired, caused the 3·6-in. gun to throw higher, and consequently range further.

Now, had the range given at 2° elevation on this occasion by the 3·6-in. gun been of an exceptional character, there might be some force

in the above reasoning; but the following table will show that the mean range of this gun at 2° elevation has been wonderfully uniform.

There cannot, therefore, be any manifest discrepancy in the range at 2° given by the 3·6-in. gun during the trial in question.

TABLE VI.

Table showing the mean ranges observed, on various occasions, of common shells (16-lb.) fired with charges of 3 lb. from the 3·6-in. 16-pr. gun.

Date of experiment.	Direction of wind.	Recoil.	No. of rounds fired.	Brand of powder.	Observed ranges.		
					Min.	Max.	Mean.
					yds.	yds.	yds.
17. 1. 71	↖	Checked.*	20	1637, R.L.G.	1144	1245	1186
1. 2. 71	↓	"	20	1637, R.L.G.	1087	1130	1115
26. 4. 71	↑ ↑	"	20	1637, R.L.G.	1106	1234	1185
8. 6. 71	→	"	20	1637, R.L.G.	1152	1208	1187
25. 8. 71	↑	"	10	1637, R.L.G.	1160	1226	1186
7. 3. 72	↙	"	10	1630, R.L.G.	1175	1229	1198
11. 3. 72	←	"	10	1630, R.L.G.	1136	1192	1168
25. 8. 71	↑	"	10	L.G., Curtis and Harvey.	1116	1219	1183
25. 8. 71	↑	"	10	L.G., 1870.†	1086	1142	1121

It appears from this table, that with the exception of the practice carried out on the 1st July and 25th August, 1871, there is a marked uniformity in the mean ranges observed at 2°.

The two exceptional ranges are probably due, in the one case to a head wind blowing against the shot, and in the other case to the use of the inferior description of powder already alluded to.

Let us now consider the question of recoil.

I wish here to direct the reader's attention for a moment to Table V. He will there observe an important note that possibly may have been overlooked by the author of "Flat Trajectories."

It appears that note *c* to Table V. informs us that the figures 18 ft. 2 in., which are given as the recoil of the 3·3-in. gun at 2° elevation, are a *mean of* 4 *rounds*.

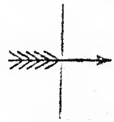
But 20 rounds were fired. Why, therefore, has not the recoil of the other 16 been included? *Because it was checked!*

Table V. is an abstract, and merely gives *mean* results, but the following tables, taken *in extenso* from the Shoeburyness report, give the result of each individual round fired from the guns at 2° elevation.

* By means of sand-bags, placed six feet behind the wheels. † From broken up cartridges.

16-*pr. M.L.R.* 3·3-*in. Gun. Experimental No.* 390.

Table VII.

No. of round.	Charge.	Elevation.	Recoil.	Projectile. Nature.	Projectile. Weight and mean weight.	Times and mean time of flight.	Ranges. 1st graze and mean.	Ranges. Difference of each range from the mean.	Deflections. Observed, right.	Deflections. Deduced.	Remarks.
	lbs.	degs.	ft. ins.		lbs.	secs.	yds.		yds.	yds.	
1	3	2	Not obsvd.	Common shell, weighted and plugged.	16	3·2	1066	9	5·0	0·3	8th June, 1871.
2	〃	〃	17 6		〃	3·1	1050	7	6·0	0·7	
3	〃	〃	18 4		〃	2·8	1007	50	5·0	0·3	Direction of wind.
4	〃	〃	17 10		〃	3·1	1062	5	5·6	0·3	
5	〃	〃	19 0		〃	3·0	1060	3	5·8	0·5	
6	〃	〃	Recoil stopped.*		〃	3·1	1035	22	5·4	0·1	
7	〃	〃			〃	3·0	1071	14	4·4	0·9	
8	〃	〃			〃	2·9	1053	4	5·6	0·3	
9	〃	〃			〃	3·1	1126	69	5·0	0·3	
10	〃	〃			〃	3·0	1040	17	5·4	0·1	
11	〃	〃			〃	3·1	1034	23	5·6	0·3	
12	〃	〃			〃	2·8	1050	7	6·0	0·7	
13	〃	〃	3 6		〃	3·0	1073	16	5·6	0·3	
14	〃	〃	4 6		〃	Not obsvd.	1087	30	6·0	0·7	
15	〃	〃	4 3		〃	3·1	1045	12	4·0	1·3	
16	〃	〃	Recoil stopped.*		〃	3·1	1108	51	4·0	1·3	
17	〃	〃			〃	3·0	1076	19	5·0	0·3	
18	〃	〃			〃	2·9	1034	23	5·4	0·1	
19	〃	〃			〃	2·9	1032	25	5·0	0·3	
20	〃	〃			〃	Not obsvd.	1026	31	6·0	0·7	
					Totals.	54·2	21135	437	105·8	9·8	
					Means.	3·0	1057	21·9	5·3	0·5	

"The gun was placed on low-level platform shot range. For rounds 13 and 15 the recoil was checked by placing a drag-shoe under each wheel, attached to the point of the trail by chain. The gun had a tendency to slew round on recoil, on account of the chain not being of quite equal length."

16-*pr. M.L.R.* 3·6-*in. Gun. Experimental No.* 385.

Table VIII.

No. of round.	Charge.	Elevation.	Recoil.	Projectile. Nature.	Projectile. Weight and mean weight.	Times and mean time of flight.	Ranges. 1st graze and mean.	Ranges. Difference of each range from the mean.	Deflections. Observed, right.	Deflections. Deduced.	Remarks.
	lbs.	degs.			lbs.	secs.	yds.		yds.	yds.	
21	3	2	Recoil stopped.*	Common shell, weighted and plugged.	16	3·4	1191	4	6·4	2·1	8th June, 1871.
22	〃	corectd. 2° 5′			〃	3.3	1190	3	5·0	0·7	
23	〃	〃			〃	3·2	1180	7	4·0	0·3	
24	〃	〃			〃	3·3	1193	6	6 0	1·7	
25	〃	〃			〃	3·3	1188	1	4·0	0·3	
26	〃	〃			〃	3·2	1186	1	3·6	0·7	
27	〃	〃			〃	Not obsvd.	1163	24	5·0	0·7	
28	〃	〃			〃	3·3	1193	6	2·8	1·5	
29	〃	〃			〃	3·2	1160	27	5·4	1·1	
30	〃	〃			〃	3·3	1208	21	3·0	1·3	
31	〃	〃			〃	3·4	1201	14	3·6	0·7	
32	〃	〃			〃	3·2	1205	18	4·0	0·3	
33	〃	〃			〃	3·4	1218	31	4·0	0·3	
34	〃	〃			〃	3·4	1193	6	2·8	1·5	
35	〃	〃			〃	3·3	1170	17	3·0	1·3	
36	〃	〃			〃	3·3	1165	22	4·2	0·1	
37	〃	〃			〃	3·4	1194	7	3·8	0·5	
38	〃	〃			〃	3·4	1192	5	4·4	0·1	
39	〃	〃			〃	3·2	1152	35	4·0	0·3	
40	〃	〃			〃	3·3	1195	8	6·0	1·7	
					Totals.	62·8	23737	263	85·0	17·2	
					Means.	3·3	1187	13·2	4·3	0·9	

"The two guns (3·3-in. and 3·6-in.) were mounted on the same carriage, and were fired alternately."

We see from Table VII. that in the case of the 3·3-in. gun the recoil of the first round was not observed. From the second to the fifth round the gun recoiled freely, and the distance is stated. From the sixth to the twelfth round the recoil was "stopped" by sand-bags placed behind the wheels. From the thirteenth to the fifteenth it was "checked" by placing a drag-shoe under each wheel; and for the remainder of the rounds it was "stopped" as above.

The range, however, was practically unaffected by the nature of recoil. Whether the recoil was free, was "stopped," or was "checked," the range was practically the same.

We see also from Table VIII. that the recoil of the 3·6-in. gun was "stopped" in a similar manner. I cannot, therefore, admit the soundness of the conclusion that the greater range of the 3·6-in. gun at 2° "can *only* be accounted for from the fact of the 3·3-in. gun being allowed to recoil, while the recoil of the 3·6-in. gun at the same elevation was checked."

But this leads us to another point that has a most important bearing on this question of recoil.

What is the meaning or significance of the words "Recoil checked," "Recoil stopped?"

Do they mean that the gun is lashed down so as to be almost immoveable; or that the free motion backwards of the gun and carriage is *immediately* subjected to restraint?

Nothing of the kind. These terms, which are interchangeable, only signify that some means has been taken to prevent the gun and carriage from *running off* the platform on which the practice takes place.

The note to Table VII. informs us that "the gun was placed on low-level platform, shot range."

This means that during practice the gun and carriage stood upon a wooden platform placed on the Shoeburyness sands at one extremity of the "shot range"—viz., a particular line of pegs 50 yds. apart.

This platform is of limited length, and is surrounded by the muddy sands; if, therefore, the recoil of a gun is too lively, or the surface of the platform—which is covered by the tide at high water—more "slimy" than usual, the recoil is "checked" or "stopped."

There are various ways of doing this. Sometimes a couple of hand-spikes or a few sand-bags are laid behind the wheels; sometimes a drag-shoe is so placed that the wheel takes it on recoil—but in any case the gun and carriage move freely for some distance before the "checking" process is brought into play. In the case under discussion, the gun and carriage recoiled freely for 6 ft.

Let us see now what effect the *quickness* of recoil would, under such circumstances, have on the angle at which the shot leaves the bore.

The investigations of the Committee on Explosives have shown that with R.L.G. powder, a projectile having a muzzle velocity of about 1300 f.s., takes about 0·0075 sec. to travel through the bore.

Let us assume that the 16-pr. shell has taken even 0·01 sec. It is evident that this represents the time during which the recoil may affect the projectile, since its having any effect is "on the supposition that the recoil commences before the shell is clear of the muzzle."

How far, then, is it probable that the gun and carriage, weighing together 2664 lb., would have recoiled in the one-hundredth part of a second? Is it likely that the difference in quickness of recoil—even if such existed—between the 3·3-in. and 3·6-in. guns would in this time have had the smallest appreciable effect on the angle of departure of the projectile?

During the trial of the 3·3-in. and 3·6-in. guns, the recoil was "*checked*" by means of sand-bags placed *six feet in rear of the wheels.* The recoil was *unchecked* up to the sand-bags. Under these circumstances, is it possible that the checking could have had the slightest effect whatever? Would not the shell have been out of the muzzle, either at 2°, 5°, or 10° elevation, long before the gun had recoiled 6 ft.?

Let me not be misunderstood. I am not here arguing that the angle of projection is unaffected by the reaction of gun and carriage. It is a well-known fact that the apparent elevation of a gun is increased by an—as it were—involuntary movement of the system on the discharge of the piece.* This motion, or tendency which the gun and carriage have to rotate on the trail, is however quite distinct from any backward motion of the wheels. Experiment has shown that this "jump" which the system makes before the projectile leaves the muzzle is much affected by the nature of the rifling. A breech-loading gun in which the shot is forced through the bore, "jumps" more than a muzzle-loading gun of the same weight and length.

There have been several experiments made, from time to time, with a view of ascertaining the value of the "jump" with different guns, and the results, on the whole, show that (*cæteris paribus*) the preponderance of a gun, or the method in which the breech is attached to the elevating arrangement has no appreciable effect.†

Now, the difference in preponderance between the 3·3-in. and 3·6-in. guns was only 1 lb. Both guns were fired off the *same* carriage and *same* nature of ground. I think, therefore, that, looking to the above facts, it is exceedingly improbable that the 3·6-in. gun threw higher than the 3·3-in.; and that in the absence of some more satisfactory reason than the one alleged, it is only fair to assume that the observed ranges are correct, and the calculated ranges incorrect.

The following table gives the results of some trials to ascertain the "jump" of various guns.

The method usually followed at Shoeburyness in carrying on such experiments, is this:—

A wooden target, 9 ft. square, is erected at 120 ft. from the gun. The axis of bore of the latter is truly levelled by a quadrant, so as to be horizontal. The corresponding height of this level is then found on the target by a theodolite. The gun is then fired, and the position of the hits on the target determines the amount or value of the "jump." It is evident that if there were no "jump," the

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* See "Second Report on Ballistics," by Captain W. H. Noble, R.A. 1865, p. 268.

† See "Report of Special Committee on Field Artillery Equipment for India." 1869, p. 25. The results of these experiments have recently been corroborated by similar trials in France.

shot should strike below the level on the target. The instant the projectile leaves the muzzle, it commences to fall by gravity, and the distance it will drop in 120 ft. can be found from the equation

$$S = \tfrac{1}{2}gt^2;$$

in which

$S =$ distance fallen in ft.,

$g =$ force of gravity $= 32{\cdot}2$,

$t =$ time taken by the shot in passing over 120 ft.

If the projectile strikes above the level, the "jump" or angle of departure can be found from the equation

$$\tan e = \frac{a + S}{x};$$

where

$e =$ angle of departure,

$a =$ mean height above level in ft.,

$S =$ distance fallen by gravity in ft.,

$x =$ distance from muzzle of gun to target in ft.

For example, the mean height above the level on a target at 120 ft. struck by three rounds from the 12-pr. rifled B.L. gun, was 8·7 ins., or 0·7250 ft. The mean velocity of the projectile was 1143 ft.; therefore the mean time of passing over 120 ft. was 0·1029 sec. Therefore

$$\begin{aligned} S &= 16{\cdot}1 \times (0{\cdot}1029)^2 \\ &= 0{\cdot}1775 \text{ ft.}, \\ \text{and } a + S &= 0{\cdot}7250 + 0{\cdot}1775 \\ &= 0{\cdot}9025 \text{ ft.}; \end{aligned}$$

so that

$$\begin{aligned} \tan e &= \frac{0{\cdot}9025}{120} \\ &= {\cdot}007521, \\ \text{and } e &= 25'\ 51''. \end{aligned}$$

That is to say, when the 12-pr. rifled B.L. gun was fired with the axis of the bore horizontal, or apparently with no elevation, the shot really issued from the muzzle at an angle, or with an elevation, of about 26 minutes.

Table IX.

Table giving in detail the results of practice carried on at Shoeburyness, on various occasions, to ascertain the "jump" of different guns:—

No. of round.	Gun, and date of experiment.	Weight of charge.	Weight of projectile.	Recoil.		Height of centre of hits above horizontal level.		Mean velocity in 40 yds.	Mean time of passing over 40 yds.	Distance fallen, due to gravity = S.	Total value of a + S.	Angle of departure = e.
				Nature.	Amount.	Individual.	Mean, = a.					
		lb. oz.	lb.		ft.	ins.	ins.	ft.	secs.	ins.	ins.	′ ″
1	16-pr. R.M.L. No. 384, 21. 11. 72.	3 0	16·0	Checked*	4·5	3·0						
2	″	″	″	″	″	1·7	2·14	1344	·0893	1·54	3·68	8 47
3	″	″	″	″	″	1·7						
4	″	″	″	Free	15·0	2·4						
5	″	″	″	″	14·0	1·9						
6	″	2 8	″	″	12·0	1·6						
7	″	″	″	″	12·0	2·2						
8	″	″	″	Checked*	4·0	1·2	2·16	1266	·0948	1·74	3·90	9 19
9	″	″	″	″	″	4·0						
10	″	″	″	″	″	1·8						
1	12-pr. R.B.L. No. 324, 21. 11. 72.	1 8	11·5	Free	6·0	7·4						
2	″	″	″	″	″	9·2	8·7	1143	·1050	2·13	10·83	25 51
3	″	″	″	″	″	9·2						
1	4-pr. R.B.L. No. 1347, 25. 11. 72.	1 1·6	9·37	″	5·0	11·7						
2	″	″	″	″	″	9·9	11·36	1166	·1029	2·05	13·41	32 1
3	″	″	″	″	5·5	12·7						
4	″	″	″	″	″	10·0						
5	″	″	″	″	″	12·5						
1	9-pr. R.M.L. No. 366, 23. 4. 69.	1 5	9·0	″	not taken	6·8						
2	″	″	″	″	″	4·7	3·83	1247	·0962	1·79	5·62	13 25
3	″	″	″	″	″	3·8						
4	″	″	″	″	″	1·7						
5	″	″	″	″	″	4·5						
6	″	″	″	″	″	1·5						

It is evident from the foregoing table that the angle of departure is not appreciably affected by the recoil being checked; and that the gun that had the quickest recoil *in reality*† threw *lower* than the other guns.

We now come to that part of the subject which refers to the recommendations of the Committee under whose supervision the trial of the two guns took place.

It must here be remarked, that I write simply as a member of the Royal Artillery Institution, and not as a member of a Committee.

It appears that during the discussion which followed the reading of "Flat Trajectories," an officer remarked that, "although the Committee on the 16-pr. field gun had reported in favour of the 3·6-in. bore, all who had heard the arguments (of the lecturer) were probably convinced that the 3·3-in. would be better."

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* By a break on each extremity of axletree.

† See p. 255, line 5.

No one disputed this statement, and the conclusion seems to have been taken for granted.

As before mentioned, it is, I think, to be regretted that no one spoke on the other side; but however desirable it may be that professional questions should be dispassionately discussed,* it would scarcely be expedient that members of a responsible Committee should, during the labours of that Committee, defend their proceedings in the theatre of the Royal Artillery Institution. Yet they are, probably, the only people who are sufficiently conversant with the facts of the case under discussion to be able to refute an attack, or reply to adverse argument. So far from the 3·3-in. bore being the best, it might easily have been shown in a few words that the Committee could not, consistently with their duty, have adopted that calibre.

Let us, however, trace the history of this trial between the 3·6-in. and 3·3-in. guns.

On the 10th September, 1870, the Director of Artillery pointed out to the President of the above Committee that it was very desirable that no time should be lost in carrying out experiments, and making a preliminary report whether the 9-pr. bronze smooth-bore guns would convert into serviceable rifled guns, and, if not, whether bronze is well adapted for guns of large calibre for field service.†

On the 14th September, 1870, a design for an 18-pr. wrought-iron M.L. gun of 11½ cwt. and 3·7-in. bore, was completed in the Royal Gun Factories; and on the 16th, the Director of Artillery proposed that as the introduction of a muzzle-loading rifled field gun of large calibre is a question of so much importance, a gun should be made of wrought-iron, to throw a shell of about 18 or 20 lb., and experiments carried on with it in comparison with bronze.‡

On the 20th September, the Director of Artillery asked whether the Special Committee had any suggestions or remarks to offer before the gun was ordered.§

On the 21st September, the President stated that the Committee were of opinion that it is not desirable to convert existing 9-pr. bronze smooth-bore guns into rifled guns, and had agreed that the following particulars should be adopted for the two proposed guns.

Weight, between 11½ and 12½ cwt.; calibre, between 3·5 ins. and 3·7 ins., "whichever might be found best suited to a shrapnel weighing from 16 to 17 lbs., and common shell about 3 calibres."‖

In their report, the Committee, after recapitulating the experiments and arguments which led to the abandonment of all attempts to utilise the existing stock of 9-pr. bronze S.B. guns, remark:—

"It was resolved, then, to experiment with two guns—one to be constructed of wrought-iron with steel tube, of the same general character

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* "The benefit of such papers was not confined to those who had the advantage of hearing them. Their chief value was in disseminating correct information through the service in print."—"Proceedings R.A. Institution," Vol. VII. p. 292.

† "Extracts." 1871. Vol. VIII. pp. 341-2.

‡ Ibid.

§ Ibid.

‖ Ibid. The words within the inverted commas are taken from the original minute.

as one a design for which had been prepared in the Royal Gun Factories; the other to be made of bronze, with only such differences from the wrought-iron gun as would be necessitated by the difference of material. It was recommended that both guns should weigh from $11\frac{1}{2}$ cwt. to 12 cwt., with a preponderance not exceeding 10 lbs.; that their calibre should be between 3·5 ins. and 3·7 ins., whichever might be found best suited to a shrapnel shell weighing from 16 lbs. to 17 lbs., and a common shell about 3 calibres in length; and the rifling should have a uniform pitch of 1 turn in 30 calibres; and that the service charge should be 3 lbs."*

Acting on the above recommendation, the Superintendent Royal Laboratory, on the 29th September, submitted drawings of shrapnel and common shell for a **3·5-in.** calibre, to weigh respectively 16·5 lbs. and 16 lbs.†

The Superintendent Royal Gun Factories, on the 8th October, 1870, submitted a drawing of a 16-pr. wrought-iron muzzle-loading rifled shell gun of **3·6-in.** calibre.‡

Thus the officer responsible for the ammunition, and the officer responsible for the gun, both selected 3·6 inches as the most suitable calibre.

These drawings being approved, the manufacture of the experimental guns and ammunition was sanctioned.

Subsequently, the trial of the bronze gun was deferred, but the wrought-iron 3·6-in. gun was issued on the 3rd January, 1871, and first fired at Shoeburyness on the 17th January, 1871. This gun weighed 11 cwt. 2 qrs. 21 lb.; calibre, 3·6 inches; length of bore, 68·4 inches; length of gun over all, 78 inches. It fired common shell of 16 lb. weight and 1 lb. 1 oz. capacity, with a charge of 3 lb.; and double common shell of 25 lb. weight and 1 lb. 8 oz. capacity, with $1\frac{1}{2}$ lb. charge.

The result of the trials led the Committee, on the 23rd January, 1871, to report that the "range and accuracy are very satisfactory; the recoil appears to come within manageable limits; and they are of opinion that the manufacture of such guns as are required for the service may be at once proceeded with up to the point of rifling."§

These recommendations were approved, and the manufacture of the guns was ordered to proceed, 2nd February, 1871.||

On the 17th February, the author of "Flat Trajectories" read a paper entitled "The Merits of a Large Bore and Small Bore Contrasted,"¶ in the theatre of the Royal Artillery Institution.

This paper advocated the adoption of a 3·3-in. calibre for the 16-pr. gun of 12 cwt., on the grounds—that the power of the gun would be increased in the proportion of 1469 to 1234—these figures representing the weight of the projectile in pounds divided by the square of its

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* "Report I., 16-pr. Rifled Muzzle-loading Field Gun." 1872. p. 2.
† "Extracts," Vol. VIII. p. 342.
‡ Ibid. p. 343.
§ Ibid. Vol. IX. p. 55.
|| Ibid.
¶ "Proceedings R.A. Institution," Vol. VII. p. 273.

diameter in inches; that the 3·3-in. shrapnel shell would contain a greater number of larger bullets; and that the common shell (3·3-in.) would hold half-an-ounce more bursting charge.

The theoretical advantage of a small calibre is beyond dispute. That a 16-lb. shell of 3·24 ins. diameter might be expected, *cæteris paribus*, to experience less resistance from the air than a 16-lb. shell of 3·54 ins. diameter, is self-evident. There are, however, other considerations that enter into the question, and that must be taken into account. The resistance of the enemy must be looked to, as well as the resistance of the air.*

A small calibre for a field artillery shell gun may entail several disadvantages—

(1) There are constructive objections to a long shell, particularly a long shrapnel shell.

(2) The sharper pitch to the rifling, which the long projectile is said to render necessary,† has a prejudicial effect on the cone of dispersion, in the case of shrapnel fire.

(3) There is a difficulty in making efficient double shell for small calibres.

Looking, however, to the theoretical advantages which the smaller bore undoubtedly possessed, and to the statements made with respect to the capacity of the projectiles,‡ the Committee, on the 6th March, 1871, recommended the manufacture of a 16-pr. wrought-iron muzzle-loading gun of 3·3-in. calibre, for the following reasons, viz:—

(1) "They believe that a 3·3-in. calibre is theoretically the best for a 16-pr. gun, as giving a greater velocity at 1000 yds., and at all following ranges, over a gun of 3·6-in. calibre.

(2) "A shrapnel shell adapted to a 3·3-in. calibre takes an equal number of bullets, and is lighter than that for a 3·6-in. calibre.

(3) "A common shell for the 3·3-in. calibre, and of the same weight as that for the 3·6-in. calibre, holds ¾ oz. more charge." §

Perhaps it would have been better had the Committee stated that the conclusions drawn in (2) and (3) were the result of estimates.

This recommendation was followed naturally by another, on the 7th March, 1871, recommending the suspension of the manufacture of 16-pr. guns, pending the contemplated experiments with the 3·6-in. and 3·3-in. guns. In referring to the proposed trial of a 3·3-in. gun, the Committee say in their report—

"The attention of the Committee was drawn to the advantage of a 3·3-in. bore for a 16-pr. gun, for which bore it was contended a projectile might be constructed capable of sustaining velocity longer than any other projectile of the same weight.

"Comparing such a projectile with one for the 3·6-in. bore, it appeared

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* See p. 248, line 31.

† "Proceedings R.A. Institution," Vol. VII. p. 285.

‡ Ibid.

§ "Extracts," Vol. IX. p. 116.

that, supposing them to start with the same initial velocity of 1350 ft. per second, the remaining velocity at 1000 yds. would be—of the former 1052 ft. per second, of the latter 1020; at 2000 yds., of the former 920 ft., and of the latter 889.

"It was agreed to make trial of a gun of 3·3-in. calibre, as it was found that the useful capacity of the shrapnel shell would not be materially affected by the decrease of diameter."*

On the 28th March, 1871, authority was given to manufacture a 3·3-in. gun, and demands were made on the 31st March, 1871, upon the Royal Gun Factories for the gun, and upon the Royal Laboratory for projectiles.

The gun was issued to Shoeburyness on the 11th May, 1871, and was subsequently, by request, placed at the disposal of the Superintendent Royal Laboratory, to enable that officer to make preliminary experiments with projectiles. This course is usually followed, and the 3·6-in. gun had been similarly placed at the disposal of the Royal Laboratory on the 18th January, 1871.

The following table gives the particulars of the projectiles supplied by the Superintendent Royal Laboratory for the two guns.

Table X.

Table giving particulars of projectiles for 3·6 and 3·3-in. guns forwarded from Royal Laboratory on the 14th April, 1871.

Calibre.	Projectile.				
	Nature.	Contents of shrapnel.	Length.	Total weight.	Bursting charge.
			ins.	lb. oz.	lb. oz.
3·6	Shrapnel	63 bullets at 18 per lb., and 56 at 34 per lb.	9·35	16 3½	—
3·6	Common	—	10·20	16 0	1 1
3·6	Shrapnel	72 at 18 per lb.	10·05	16 14½	—
3·6	Common	—	10·8	16 14½	1 2¼
3·3	Shrapnel	72 at 18 per lb.	11·3	16 1	—
3·3	Common	—	11·3	16 0	0 15

On the 3rd June, 1871, the Superintendent Royal Laboratory stated that "the trial of shrapnel shells in the 3·3-in. gun at Shoeburyness has not proved satisfactory—three out of six having broken in the gun.

"It is evident that with this long shell and more rapid spiral, greater thickness is necessary; this will reduce the capacity considerably."†

It is scarcely surprising that on receipt of this it was decided that no further steps be taken for the manufacture of shrapnel shells

* "Report, 16-pr. Muzzle-loading Rifled Field Gun." 1872. p. 2.
† Extract from a letter addressed to Committee.

for the 3·3-in. gun "till after the trial of the gun for initial velocity, range, and accuracy."

This trial appears to have been carried out with the least possible delay—namely, within four days of the receipt of the report with respect to the unsatisfactory behaviour of the shrapnel shells.

The results, given in the foregoing tables (II. and V.) must, I think, convince any unprejudiced mind that whatever theoretical advantages the smaller calibre might possess, the practical advantages were quite inappreciable. The case therefore, at this stage, stood as follows:—

On the one hand, it had been calculated that the remaining velocity of projectiles fired with 3lb. charge from a 3·3-in. gun would exceed that of those fired with the same charge from the 3·6-in. gun—at 724 yds. by 1 ft., at 1000 yds. by 11 ft., at 1500 yds. by 19 ft., and at 2000 yds. by 25 ft.; these being artillery fighting ranges.

On the other hand, experiment had shown that when fired under identical circumstances as to charge, weight of projectile, carriage, platform, weather, and elevation, there was no advantage as to accuracy with either gun, but the range of the 3·6-in. exceeded that of the 3·3-in. by 130 yds. at 1100 yds., and by 56 yds. at 2200 yds.; these being artillery fighting ranges.

Again, one of the main conditions under which the trial was authorised, was that the useful capacity of the shrapnel shell should not be materially affected by the decrease of diameter; but the officer responsible for the manufacture of the projectiles had stated that "it is evident that with this long shell and more rapid spiral, greater thickness is necessary; this will reduce the capacity considerably."

Moreover, the whole manufacture of shell guns for field service had been at a stand-still for three months, pending the settlement of this controversy as to calibre. The case, therefore, might be argued somewhat as follows:—

Looking to the comparatively small theoretical advantage as to power possessed by the 3·3-in. calibre; to the fact that at equal elevations its range, at fighting distances, is less than that of the 3·6-in.; to the unfavourable opinion of the Superintendent Royal Laboratory as to projectiles; to the fact that even the theoretical advantages of the smaller calibre would disappear if the weight of the projectile for the 3·6-in. calibre was increased to that originally contemplated by the Director of Artillery*—a course which it might hereafter be found advisable to adopt; and to the desirability of losing no further time in manufacturing shell guns for service—is it worth while to continue experiments in this direction?

The Committee appear to have answered this question in the negative; and, under the circumstances, I, for one, cannot possibly see how, consistently with their duty and the merits of the case, they could have come to any other decision.

February, 1873.

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* See p. 262, line 27.

DETAILS OF THE FIELD ARTILLERY OF THE PRINCIPAL FOREIGN EUROPEAN STATES.

	Prussian.		French.			Austrian.		Russian.		Italian.	
	8 c.m. 4-pr.	9 c.m. 6-pr.	4-pr.	8-pr.	12-pr.	4-pr.	8-pr.	4-pr.	9-pr.	8-pr.	16-pr.
Calibre, in centimetres	7·85	9·16	8·65	10·61	12·13	8·08	10·04	8·67	10·67	9·58	12·12
Weight of carriage (without gun, &c.) in kilos.	450	516·5	372	—	579	420	580	437	482	515	520
Weight of gun (including stopper) in kilos.	steel, 301·5 bronze, 305	432·5	330	575	610	263	498	stl. 309–318 bronze, 337–348	steel, 626 bronze, 628	390	730
Wht. of car. with gun complete for serv., in kilos.	785·5	1018·5	728	—	1223	700	1115	837	1108	904	1250
Wht. of limber (without amtn. and eqpt.) in kilos.	452·5	458·5	412	—	517	334	370	405	405	503	503
do. (equipment for service) in kilos.	786·5	816·5	544	—	714	501	613	516	—	911	907
Weight of gun equipment for service, in kilos.	1572	1835	1272	1830	1937	1201	1728	1353	—	1815	2157
" Amtn. wagon eqt. for service, in kilos.	F.B. 1965 H.B. 2078	2212	1641	1760	2048	F.B. 1544 H.B. 1589	1966	1019	—	2246	2379
No. of rounds in the limber to be added to: Shell	36	24	33	20	15	22	18	8	2	50	22
Shrapnel	8	6	4	2	2	10	8	6	6	—	—
Case	4	3	3	2	1	4	4	4	4	5	2
Total	48	33	40	24	18	36	30	18	12	55	24
Case in gun carriage	1	1	—	—	—	4	4	—	—	—	—
Case in axle-tree boxes	—	—	4	—	—	—	—	—	—	—	—
No. of rounds in wagon limber: Shell	36	24	33	20	15	22	18	no limbers	no limbers	50	22
Shrapnel	8	6	4	2	2	10	8			—	—
Case	8	6	3	2	1	4	4			5	2
Total	52	36	40	24	18	36	30			55	24
No. of rounds in wagon body: Shell	32	42	66	40	30	66	52	26	18	64	44
Shrapnel	24	21	8	4	4	4 carcasses 10	4 carcasses 8	5 carcasses 22	4 carcasses 12	—	—
Case	—	—	6	4	2	—	—	3	2	16	4
Total	56	63	80	48	36	80	64	56	36	80	48
Total No. of rounds in ammunition wagon	108	99	120	72	54	116	94	56	36	135	72
The battery has: Guns	6	6	6	6	6	8	8	8	8	6	6
Ammunition wagons	6	6	8	—	12	8	8	16	24	6	10
Total No. of rounds per gun	157	133	204	—	126	156	128	130	120	(a) 199	148
No. of horses per: Gun	6	6	4	6	6	F.B. 4, H.B. 6	6	F.B. 4, H.B. 6	6	6	6
Ammunition wagon	6	6	4	6	6	F.B. 4, H.B. 6	6	3	3	6	6
Weight per horse, in kilos.: Gun	262	306	318	305	323	F.B. 300 H.B. 200	288	F.B. 338 H.B. 226	—	302	359
Ammunition wagon	F.B. 328 H.B. 346	369	410	293	341	F.B. 386 H.B. 265	328	340	—	374	396
No. of men that can be mounted: on the limber	3	3	2	3	3	3	3	3	3	3	—
" gun carriage	2	2	—	—	—	1	2	2	2	3	—
" ammunition wagon	6	6	4	5	5	3	3	—	—	—	—
" off horses	—	—	—	—	—	2	3	—	—	—	—
Weight of gun with mounted men, in kilos.	(b) 1997	2260	1442	2085	2192	1541	2153	1778	—	2070	—
" ammunition wagon, do. do.	2475	2722	1981	2185	2473	F.B. 1799 H.B. 1844	2221	—	—	—	—
Weight per horse, men mounted: Gun, in kilos.	333	377	361	348	365	F.B. 385 H.B. 257	359	445	—	345	—
Ammunition wagon	413	454	495	364	412	F.B. 450 H.B. 307	370	—	—	—	—
Height of fore wheel, in c.m.	123·5	123·5	143	149	149	110·6	110·6	122·0	120·0	148·0	148·0
" hind " "	154·84	154·84	143	149	149	134·4	134·4	137·2	137·2	148·0	148·0
Width of tire, in c.m.	6·5	6.5	6	7·5	7·5	—	—	—	—	—	—
Material of studs, &c.	bronze.	bronze.	bronze.	bronze.	bronze.	cast-iron.	cast-iron.	bronze.	bronze.	bronze.	bronze.
System of gun	B.L. with dble. wedge.	B.L. with piston.	M.L.	M.L.	M.L.	M.L.	M.L.	B.L. with wedge	B.L. with wedge	M.L.	M.L.
System of taking the rifling	lead coatg.; no windage.	lead coatg.; no windage.	studs.	studs.	studs.	ribs.	ribs.	lead coatg.; no windage.	lead coatg.; no windage.	studs.	studs.
Length of the rifling, in c.m.	151·31	154·31	127	—	170·7	108	133	steel, 119·3 bnze., 121·3	145·2	130·6	177·4
No. of grooves	12	18	6	6	6	6	8	12	16	6	6
Angle of rifling	3° 45′	3° 30′	6° 53′ 10″	—	7° 14′ 20″	8° 30′	8° 30′	4° 22′ 54″	3° 35′ 43″	6° 17′ 47″	6° 43′ 41″
Metal of gun	wt. cst. steel (c) bronze.	wrt. cast steel.	bronze.	bronze.	bronze.	bronze.	bronze.	wt. cst. steel bronze.	wt. cst. steel bronze.	bronze.	bronze.
Weight of loaded shell, in kilos.	4·34	6·90	4·00	7·36	11·50	3·622	6·580	5·530	11·050	4·50	11·13
Burster, in grammes	166·6	250	200	400	500	200	438	203	410	300	500
Weight of loaded shrapnel, in kilos.	4·60	7·33	4·718	8·75	11·79	3·983	7·367	6·65	12·773	—	—
Burster, in grammes	8·5	17	85	—	200	66	127	75	110	—	—
No. of balls in shrapnel	lead, 90	lead, 180	lead, 85	lead, 100	lead, 150	lead, 80	lead, 140	ld. and anti. 36	ld. and anti. 71	—	—
Weight of single balls, in grammes	16·7	16·7	19·2	19·2	27·7	12·5	12·5	24	24	—	—
Weight of case, in kilos.	3·75	5·25	4·725	8·100	11·22	3·746	6·458	4·98	12·764	6·44	12·75
" single shot in case, grammes	50	83·3	70	70	70	52·6	70	91	91	100	206
No. of shot in case	zinc, 48	zinc, 41	cast-iron, 41	cast-iron, 70	cast-iron, 98	zinc, 56	zinc, 67	ld. and anti. 48	ld. and anti. 108	iron, 41	iron, 41
Service charge, in kilos.	0·5	0·6	0·55	0·8	1·0	0·525	0·928	0·625	1·24	0·9	1·2
Proportion of charge to shell	1/8·68	1/11·5	1/7·27	1/9·2	1/11·5	1/6·9	1/7·1	1/8·84	1/8·9	1/5	1/9·2
Initial velocity, in metres	341	323	325	—	307	333	343	306	320	387	330
Velocity in metres at: 500 m.	301	295	283	—	280	281	271	285	287	—	—
1000 m.	271	274	248	—	255	247	229	268	271	—	—
1500 m.	248	257	220	—	231	222	201	255	258	—	—
2000 m.	230	244	194	—	210	204	182	243	246	—	—
2500 m.	217	232	170	—	189	190	168	232	236	—	—
3000 m.	205	220	149	—	169	178	156	223	227	—	—
Elevation, Angle of descent, at 500 paces = 376·6 m.	0° 41′ 1° 6′	0° 58′ 1° 11′	0° 51′ 1° 5′	—	0° 55′ 1° 10′	0° 53′ 1° 9′	1° 0′ 1° 14′	1° 2′ 1° 10′	0° 52′ 1° 2′	0° 48′ 0° 55′	1° 3′ 1° 8′
Do. do. at 1000 paces = 753·2 m.	1° 51′ 2° 17′	2° 9′ 2° 30′	2° 1′ 2° 36′	—	2° 19′ 2° 51′	1° 58′ 2° 42′	2° 0′ 2° 40′	2° 15′ 2° 34′	2° 0′ 2° 18′	1° 53′ 2° 20′	2° 16′ 2° 34′
Do. do. at 1500 paces = 1129·9 m.	3° 0′ 3° 36′	3° 23′ 3° 56′	3° 24′ 4° 42′	—	4° 2′ 5° 8′	3° 24′ 4° 56′	3° 22′ 4° 20′	3° 35′ 4° 10′	3° 12′ 3° 44′	3° 12′ 4° 22′	3° 40′ 4° 28′
Do. do. at 2000 paces = 1506·5 m.	4° 15′ 5° 11′	4° 45′ 5° 34′	5° 9′ 7° 24′	—	6° 5′ 7° 58′	5° 15′ 7° 8′	4° 51′ 6° 12′	5° 0′ 6° 0′	4° 30′ 5° 22′	4° 49′ 7° 10′	5° 15′ 6° 40′
Do. do. at 3000 paces = 2259·7 m.	7° 17′ 9° 6′	7° 49′ 9° 21′	9° 20′ 14° 59′	—	10° 37′ 15° 4′	9° 36′ 14° 2′	8° 27′ 11° 46′	8° 20′ 10° 40′	7° 24′ 9° 20′	9° 13′ 14° 56′	9° 6′ 12° 37′
Do. do. at 4000 paces = 3013 m.	10° 56′ 14° 23′	11° 26′ 14° 8′	15° 27′ 25° 52′	—	16° 25′ 24° 30′	15° 51′ —	13° 21′ 22° 37′	12° 30′ 17° 6′	10° 51′ 14° 18′	15° 33′ 26° 31′	14° 6′ 20° 42′

Abbreviations.—F.B., field battery; H.B., horse artillery battery; c.m. = ·39″; m. = 39·37″; kilog. = 2·20462 lbs.; 1000 k. = 1 ton.

(a) The Italian batteries have a spare gun-carriage, with limber packed; the number of rounds per gun is therefore proportionally increased. (b) A man's weight = 187 lbs. = 85 kilos.

(c) In 1870–71, 13 reserve batteries were equipped with 8 c.m. bronze guns.

The foregoing table lays no claims to originality, but has been taken from a German publication which appeared in 1872, on the "Field Artillery of the European Powers." It has been thought that the table may be of service to the regiment.

E. O. H.

THE

CHARACTERISTICS OF MODERN BATTLES.

Translated from the "Militärische Gedanken und Betrachtungen über den Deutsch-Französischen Krieg der Jahre 1870 und 1871," with the permission of the author—a German General,

BY

CAPTAIN HIME, R.A.

Military history teaches us that the tactics of every period are marked by certain peculiar characteristics; that these characteristics change slowly, but surely, with the revolution of time and the progress of improvement; and that this transformation takes place in such a manner, that conditions which in one age are of secondary consideration, become in the succeeding age of primary importance. It is unnecessary to go back further than the time of Frederick the Great to seek the origin of the peculiarities which characterise modern battles. The distinguishing mark of the tactics of his time was the system of firing by lines. Armies were drawn up in long, rigid, continuous lines, and that army was victorious which succeeded first in effecting, by its fire, a breach in the enemy's line, and, by forcing troops through the breach thus created, destroying the continuity of his line. The infantry was then the principal arm—the artillery merely serving to strengthen the long lines of its own infantry, and to weaken by its fire the point in the enemy's line which it was intended to force. The artillery, consequently, was the least of the three arms. The cavalry, on the other hand, often became the principal arm, when by a daring charge it was successful in forcing a point in the enemy's line. But such exploits were only of occasional occurrence; for in order to avoid disturbing the continuity and compactness of its own infantry lines, the cavalry had to be posted on the flanks, where it found itself opposed, for similar reasons, by the enemy's cavalry. It was only possible, therefore, for this arm to take a leading part in forcing the enemy's lines of infantry after his cavalry had been driven from the field.

While such was the character of battles, success naturally depended on the capacity of manœuvre, or mobility, of an army; since the greater its mobility, the more freely and rapidly could it be put in motion against any given point of the enemy's front, without destroying the continuity of its own long deployed lines. Not only this, but the possibility of withdrawing completely, or to a great extent, beyond the zone of the enemy's fire, depended upon the same quality; and the most splendid exploits of the great king

were due to the unrivalled mobility of the Prussian army. Hohenfriedberg, Prague, and Leuthen sufficiently prove that, though generally weaker than the enemy in numbers, yet, from the superior mobility of his army,[1] he was enabled almost invariably to secure the victory by falling upon the enemy, if not with superior forces, at least with the *élite* of his army. In the later battles of the Seven Years' War—especially in those against the Russians and at Torjau—a gentle transition is apparent, and in them may be found the first germ of the mode of fighting adopted by Napoleon. A careful examination of these battles proves that they were won, not by the shock of opposing lines, but by the gradual employment, in different combinations and in different formations, of the three arms.

The wars of the French revolution form the transition period to that new form of battle which Napoleon exclusively adopted. No longer formed in long, unwieldy lines, the infantry was divided into distinct manageable bodies, called battalions, and by this means gained an independence and capacity of manœuvre hitherto unthought of. The extended nature of the combat rendered it possible to fight on ground which in previous wars would have been looked on as impracticable, and enabled infantry that had been worsted to take advantage of the cover afforded by broken ground in larger bodies. The importance of cavalry became lessened in a corresponding degree, and its most determined and successful charges no longer exerted a decisive influence on the fate of battles, as at Hohenfriedberg. It might, indeed, ride down one or two battalions; but thrown into disorder by its own success, it became incapable of producing further useful results. On the other hand, the artillery gained in importance as the cavalry lost. From its increased range, it could cannonade the individual masses of the enemy from greater distances than formerly, and its effect upon these masses was increased by the use of explosive projectiles. Furthermore, it was possible, by a slight change in the position of the guns, to obtain a clear view of the movements of an enemy who endeavoured to advance unobserved to the attack, and the batteries were enabled, by their superior mobility, to concentrate with greater rapidity upon important points.

Instead of the long lines of the Seven Years' War, troops were now formed in deep masses, from which the line of battle was continually fed with fresh forces. The duration of the fight increased, and he was the victor who brought up the last reserve of fresh troops against the spent troops of his adversary. The weary hours during which battles now raged were "long drawn out" by the imperfection of the infantry fire-arms; but this did not necessarily involve greater slaughter than formerly; for as the heaviest artillery was innocuous beyond 2000 paces, it was possible to post reserves in positions from which, although beyond the zone of the enemy's fire, they could reach the line of battle in a few minutes. In consequence of the principle of "the last fresh reserves," victory usually inclined to the side which was numerically the strongest. Indeed "heaven favours big battalions," as a general rule, and only rarely and under peculiar circumstances is it pos-possible for the few, by rapid successes, to defeat the many. When the

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[1] For a brief sketch of the gradual improvement in the mobility of armies, see "Geschichte des Geschützwesens und der Artillerie in Europa." Von C. von Decker. Berlin, 1822. p. 144, *et seq.*—Tr.

contending forces were large, the system of gradually employing the reserves considerably increased the duration of battles. They frequently lasted from "morn till dewy eve," and more than one of Napoleon's battles raged for several days.[1]

It naturally resulted that the grand object of army organisation, at the time of which I speak, was to form the largest armies possible, while the grand object of tactics was to bring the strongest army upon the field; and victory attended the general—not only in a single battle, but throughout whole campaigns—who succeeded in accomplishing both these objects best. Napoleon was not only a master of organisation, but of tactics; and Victory fluttered round his eagles until united Europe, "beaten into efficiency"[2] by years of disaster, learned the secret of his successes, and opposed him with larger forces than France could bring into the field.

During the long peace that followed Waterloo, the military world was engaged in sifting the experience afforded by the wars of the French revolution and Empire, and in improving the construction of fire-arms. As the progress of fire-arms depends on the progress of chemistry and metallurgy, it would be idle to enquire whether those which we now possess have reached a state of absolute perfection; for each fresh discovery in these sciences will no doubt lead to a corresponding improvement in fire-arms. It may not, however, be out of place to say a few words on the range, accuracy of fire, and rapidity of fire, of fire-arms at the present time. As regards the first, the range of the muskets and field guns in general use rivals, if it does not surpass, that of human vision; in other words, it has reached its utmost useful limit. In accuracy of fire, such advances have been made that a large proportion of shot, within certain limits, may be expected to hit. The rapidity of fire, of muskets at least, has increased to a very great extent, and a rifle can now be loaded quicker than it can be fired. Improvements may undoubtedly be made in the rapidity of fire of field guns, and the explosive effects of shells; but it will be time enough to estimate the effect these improvements will produce on war when they have been introduced. The improvements in fire-arms, and the proportionally greater effect which they produce, gave rise in America, during the War of Secession, to a mode of fighting never before witnessed. When the opposing armies came within sight of each other, instead of advancing and giving battle in the ordinary way, each army carefully entrenched itself beyond the range of the enemy's fire, and merely endeavoured to gain some point or position, the occupation of which would render the enemy's field-works untenable. Such a position once gained, the enemy at once retired—but only to entrench himself again in another position. I do not mean to assert that all the battles of the war were fought in this fashion; but this indecisive mode of fighting was so frequently resorted to, that for three long years the tide of war ebbed and flowed between Washington and Richmond—cities which are scarcely farther apart than Saarbrück and Paris—

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[1] Arcola and Leipsig, for example.—Tr.

[2] I borrow this phrase from Col. Hamley's "Operations of War." In the 3rd Rhetræ of Lycurgus it was directed that war should not be made often upon the same enemy, lest he should learn the secret of the Spartan tactics. Antalcidas taunted Agesilaus with having taught the Bœotians, by constant invasions, how to fight; and the truth of the taunt was proved at Leuctra, where Cleombrotus was killed and the Spartans overthrown by Epaminondas.—Tr.

without reaching either of them. Although such a system of tactics has not yet been introduced in all its integrity into European warfare, yet the necessity for greater protection against the increased power of modern fire-arms has been already distinctly felt. In the war of 1870–71, battles lasted on some occasions for several days, simply because neither commander was willing to leave a strong position and advance across the open to attack the enemy in an equally strong position. Only small, partial attacks were made, and the result of the whole was dependent upon the results of these small, partial fights. To this category belong the combats between Meung and Marchenoir, which lasted from the 7th to the 10th December; between Vendôme and Le Mans, from the 6th to the 12th January; and perhaps those at Belfort, from the 15th to the 17th of January. In warfare of this description, success depends not so much on the numbers of the troops engaged, as on their quality, and the skill of the generals; and as in both these respects the Germans were superior, in the cases just mentioned, it was undoubtedly right for them to accept battle after this fashion when offered by the French. Further, in the first and third case, the French outnumbered the Prussians in the proportion of three to one, and in the second case the ground was so close that a general action was only possible if desired by both sides. In the present imperfect state of our knowledge as to the minor details of the war of 1870–71, it is impossible to explain how it happens that as great results may be achieved by a continuous series of minor operations as by a grand battle, but the following example will suffice to show that important successes may be achieved by such a mode of fighting.

On the 30th December, 1870, the French advanced in force against the right flank of the 10th Army Corps on the Loir. Their main body, after driving in the Prussian outposts, first encountered serious opposition at Vendôme. In order to force this position, the French sent forward a column, consisting of at least one entire brigade and two batteries, by the main road from Le Mans to Orleans, *viâ* Danze, to Etival, with a view to force the passage of the Loir at this latter place, and thus turn the position by the right. At Etival there was only the detachment of General von Lüderitz, composed of cavalry, horse artillery, and two companies of the 17th regiment of infantry. The fighting began in the close country between Danze and Etival. The cavalry could not be used, in consequence of the configuration of the ground, but an excellent position was found for the guns, to which two *zugs* of infantry were attached as escort. With the remaining four *zugs* of infantry, Capt. Spitz, by cleverly making use of a small, unobserved, deserted ravine, succeeded in advancing and taking in flank first one and then the other French battery which was engaged with the Prussian artillery. Both batteries he thus compelled to retire, capturing four guns—two from each battery. But he was not content with this success; and skilfully taking advantage of the cover which the ground afforded, he pressed the first French line back and back, operating principally against one flank. The French, feeling the enemy constantly upon their heels, retired from position to position, notwithstanding their tenfold superiority in numbers, until they finally reached Danze—the decisive point of the road from Le Mans to Vendôme and Orleans—leaving nearly 100 killed and wounded behind the hedges they had ineffectually endeavoured to defend. The result was that not only the attack on Vendôme, but all further attempts on the position of the 10th Corps had,

for that day, to be abandoned. Surely great results were thus gained by small means.[1]

It is not, however, very probable that in future European wars the grand result will be achieved by the American mode of "trench-fighting," or by a long series of partial engagements; the fate of nations will rather be decided by the issue of grand battles. Before investigating the characteristics of grand battles, it will be useful to glance at the peculiar fighting qualities of the three arms.

At the present day, fire, pure and simple, is by far the most important element in infantry fighting. Owing to the slowness of fire, want of accuracy, and limited range of the old smooth-bore musket (somewhat over 300 paces), it was formerly possible, without any very great loss, to charge the enemy quickly and decisively with the bayonet, and stake the result of the action on a hand to hand fight; but things are now changed. The range of infantry fire is so extended, and its rapidity is so increased, that it is almost hopeless to attempt to carry forward troops against an enemy in position for a bayonet attack; and even should the attempt to reach the enemy succeed, the loss of the attacking party would be so great as to preclude any reasonable expectation of success, unless they were vastly superior numerically to the enemy before the attack was made. It must not be concluded, however, that cold steel will only be resorted to under unusually favourable circumstances. Bayonet charges will always most surely pronounce a decision between two opposing bodies of infantry, from which there can be no appeal; and victory can only be made certain by closing with the enemy, and annihilating him on the spot where he stands. What I insist on is, that they should never be resorted to in the devil-may-care way which was formerly in fashion, but must be looked on as the last act of a hotly contested fight, and must be prepared with the greatest care.[2] The arm on which this preparation devolves is, as I shall presently show, the artillery; but infantry alone may suffice to prepare their own advance. However accurate infantry fire-arms may be, they can be only used effectively in action against objects sufficiently large to be easily aimed at. Now, at about 500 paces a man does not present a sufficiently large object to admit of being steadily aimed at by the great majority of private soldiers.[3] Consequently, between 500 paces and 1500 paces—the superior limit of infantry fire—a man moving singly incurs only the risk of being hit by the greater or less shower of random bullets that fall around him. The assailants can only hope for decisive results from their fire when each individual soldier aims at an individual soldier of the enemy; for shots fired at the general mass of the enemy produce but small effect. The attacker, therefore, must advance 1000 paces before his fire can produce decisive effects; *i.e.* from 1500 paces—the extreme limit of infantry fire—to 500 paces, when individual soldiers of the enemy can be effectively aimed at.

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[1] See the excellent maps which accompany General Chanzy's book, "La Deuxieme Armée de la Loire."—Tr.

[2] See Lieut. Maurice, R.A.'s "Wellington Prize Essay," p. 85.—Tr.

[3] I give the German of this sentence for the benefit of those who understand that language better than myself:—"Der einzelne Mensch hat aber diese Grösse auf 450–500 Schritt fast nicht mehr, d. h. er erscheint so schmal, dass seine Figur durch Visir und Korn nicht mehr festzuhalten ist." p. 233, *ad inf.*—Tr.

The quicker this is done, the less loss will be sustained. The first line of the attacking party, therefore, having discarded all superfluous weight beyond the range of the enemy's fire—1500 paces—should advance across these 1000 paces as rapidly as possible, in skirmishing or open order. As there are few soldiers who, when laden with a rifle and ammunition, can advance 1000 paces at a double without coming in so breathless and exhausted as to be incapable, for some minutes, of firing steadily and accurately, three or four halts should be made during the advance. There will be but few practical objections to such a course; for in almost all ground inequalities will be found every two or three hundred yards, and to troops lying down very slight irregularities are sufficient to afford cover at ranges exceeding 500 paces from the enemy. By thus lying down, the men recover their breath and self-possession, and are enabled to traverse the next portion of the space at full speed. This succession of rests and advances continues until the troops arrive on the confines of the zone of accurate fire—500 paces.[1]

Once this position is reached, the engagement with fire-arms which follows will be decided far more by the accuracy than by the rapidity of fire; for whatever may be the comparative numbers of the troops engaged, within certain limits, victory will be with the troops who, possessing the largest number of good shots, inflict the greatest material loss upon the enemy.[2] But even though the attacker possesses no superiority in accuracy of fire, still his fire will probably be more effective than that of the defender; because the latter usually affords a greater number of objects to fire at, and not only his first line of troops, but the masses posted behind them, are within the zone of the attacker's fire. The attacker should strengthen the first line of skirmishers by supports in small groups. The supports follow the skirmishers, and fill up, as circumstances demand, the gaps caused by the enemy's fire. When the enemy's fire is somewhat slackened, still larger bodies should follow in support of the skirmishers; not to advance with the bayonet, but to give greater extension to the introductory fight, and to draw the enemy's fire upon themselves. Then, and only then, after a long and complete preparation, should the troops advance who are to use cold steel. Need I say that all movements within range of the enemy's bullets must be made as rapidly as the maintenance of order and the physical energy of the men permit? Tedious though the preparation for the attack be, its result is decided with the speed of lightning. If the attack succeeds, a stubborn enemy may engage for a few minutes in a hand to hand fight; but this rarely occurs, and as a general rule the worsted defender beats a retreat beyond the effective range of fire as quick as his legs can carry him. If the attack fails, the unsuccessful attacker retreats quite as precipitately. In old times, if the charge was brought to a stand-still by the firmness of the defenders, a fight with fire-arms at close quarters frequently ensued; but owing to the murderous effect of small-arms, such a case is now scarcely conceivable. Even in such cases as village-fighting, conducted with skill on both sides, where the defender has good cover, and the attacker presses on regardless of loss, the result is not

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[1] I suggest that from 1500 to 500 paces from the enemy should, for convenience sake, be called the *zone of imperfect fire*, and the space within 500 paces from his line, the *zone of accurate fire*.—Tr.

[2] This principle shows the great importance of musketry instruction for the English infantry, who generally fight at a great numerical disadvantage.—Tr.

long delayed. Breech-loading rifles bring to a rapid conclusion village-fights which in Napoleon's time would have lasted for hours and hours; and in point of duration, the most obstinate village-fight since 1866—that at Le Bourget, 30th Oct. 1870—dwindles into insignificance when compared with Möckern, S. Amand, and Ligny. In forest-fighting only will the cool self-possession of the men decide the result, for there the man weighs more than the weapon; and accordingly long contested forest-fights still occur. In general, however, modern infantry fights are distinguished by three characteristics: first, the attack demands a much longer and more careful preparation than formerly; secondly, the attack itself occupies a much shorter time; and thirdly, the result is far more decisive.

The improvements in the field artillery service are even greater than those introduced into the infantry. By the better construction of the gun-carriages and limbers, and by the diminution of the weight of the guns, a mobility has been conferred on the field batteries which they never before possessed; and since arrangements have been made to convey into action with their guns the number of gunners required to work them, the heaviest field pieces of the present day vie in capacity of motion with the light horse artillery guns of Napoleon's time. But these improvements in mobility, great as they undeniably are, fall far short of those in the efficacy of fire of the guns. Their range extends as far as the eye can perceive a large body of men—such as a battalion in column; and their accuracy is so extraordinary that almost every large object which lies within their range can be hit, if its distance be accurately known. These advantages are, of course, attended by certain disadvantages unknown in the old guns.[1] The great accuracy of fire of the guns requires a correspondingly accurate laying in order to hit the object; and at long ranges rifled guns, like breech-loading rifles, have a high trajectory, which does not so thoroughly sweep the ground to their front as the old round shot.[2] On the other hand, the projectiles used are almost entirely shell which burst before the object; so that instead of a projectile like the old round shot, which acted only along a certain line, we have a projectile which is effective within a certain area of explosion. But beyond this area their effect is almost *nil*; and a shell which from any cause strikes too short, or a few yards too long, may be considered as ammunition thrown away, because the fragments of the shell seldom reach a second object, such as another body of troops. Finally, the new guns possess an excellent shrapnel shell, whose effect surpasses that of the shells of former times as much as the range of rifled guns surpasses that of smooth-bores. Against this, however, must be set off the time required to lay the guns accurately, and to adjust the fuze correctly.[3] Further, the canister of the new guns cannot be compared with the old canister, by means of

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[1] "Toutes les fois qu'une idée nouvelle surgit, elle amène avec elle de nouveaux avantages et de nouveaux inconvénients. L'œuvre du génie est d'établir la balance et de voir de quel côté le plateau incline."—"Etudes sur le passé et l'avenir de l'Artillerie," par l'Empereur Napoleon III. Tom. I. Avant-propos, p. xii.—Tr.

[2] "Die weite Trugfähigkeit, die schon wegen des Infanteriegewehrs meistens in Anspruch genommen werden muss, bedingt einen Bogenschuss, dem der weite bestrichene Raum, den die alten Vollkugel-geschosse hatten, fehlt." p. 237, *ad sup.*

[3] To bore the fuze correctly, the range must be known; and at the enormous ranges at which modern field guns are used, it is practically impossible to judge the distance accurately without a range-finder of some description.—Tr.

which the smooth-bores gave such terrible evidence of their presence in the midst of the most critical struggles. This, however, is a minor disadvantage; for the new infantry rifles are effective up to the extreme range at which even the old canister was useful—800 paces—and artillery fire can therefore be dispensed with within this distance.

The experience of the late war shows that the advance of guns into action at a mean range of 2000 paces, can be almost always effected without any considerable loss. This arises partly from the great mobility of the batteries, and partly from the difficulty which the enemy will experience in firing at a long range against a moving object. In old times, the first advance of the batteries against the enemy's guns posted in position was always a critical moment. Armies were separated by a shorter distance then than now; in taking ground and reversing, the batteries afforded an excellent mark; and the low trajectory of the smooth-bores rendered any small mistake in the judging of distance a matter of little importance. At the present day, an error of 60 or 70 paces on the part of the defenders, in judging distance at a mean range of 2000 paces, is sufficient to enable a battery advancing to the attack to complete its movement without loss. But it is only during this preliminary advance that the attacking artillery can move with more impunity than formerly. In the bursting of his shells the gunner possesses the most unmistakeable evidence as to whether his gun carried too long or too short; and so accurate is his gun, and so elaborate his tangent scale, that he can make allowance for an error of 25 paces. After the second or third shot, a gunner ought to be able to tell the range within 25 paces, one way or other, and make the most of the extraordinary accuracy of his gun.[1] It is impossible, however, for the artillery of the defence to aim with accuracy, at a mean range of 2000 paces, against any given single gun of the batteries advancing to the attack, in consequence of the large interval that must necessarily be allowed between the guns of a battery of field artillery.[2] It is consequently easy to understand why, in the present day, during the preliminary advance of the artillery of attack, the number of guns dismounted is less, and the loss in men and horses is not greater, than formerly, when the extreme range at which the artillery of defence commenced firing was 1000 to 1200 paces.

The larger a fixed object is, the more certainly will it be hit. At 2000 paces a battalion—aye, even a company—at the halt will seldom be missed, once the range has been exactly found by trial shots;[3] and larger

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[1] This principle was clearly stated by an English gunner 250 years ago:—"To fayle at the first shot, if the gunner be not acquainted with the Peece and Mark, is passable; and at the second to fayle is pardonable; but to fayle of a fair shott at the third time is too much, and argues but little judgment and discretion in such a gunner."—"The Gunner: shewing the Whole Practice of Artillery; by Robert Norton, one of His Majestie's Gunners and Engineers. London, 1628." The Prussians have no range-finder at the present time.—Tr.

[2] This is precisely the reason why Prince Hohenlohe-Ingelfingen recommends a rapid advance at full intervals for the artillery of attack:—"Auf diesem Grunde ist aber auch sich bewegende Artillerie Seitens des Feindes schwer zu treffen, wenn sie nur in breiterer Front entwickelt gerade auf den Feind losgeht und somit in ihren einzelnen Geschützen lauter einzelne kleine, sich bewegende Zielpunkte darbietet."—"Ideen über die Verwendung der Feld-Artillerie." Berlin, 1869. p. 42.—Tr.

[3] One of the advantages of a range-finder is, that it saves the waste of ammunition entailed by trial shots.—Tr.

objects—such as entrenchments, farms, villages—will be certainly struck, shot after shot.

But it is far otherwise with moving objects. A battalion on the move, though it alters its distance slowly, will evidently be less often struck than a battalion at the halt; and smaller bodies of men, such as companies or *zugs*, when on the move will suffer still less. Cavalry moving at a rapid pace has as little to fear from rifled guns as from smooth-bores; and when within 600 to 800 paces from the enemy—the zone within which canister was so formidable of old—troopers have less grounds for alarm than formerly.[1]

The German field artillery has proved itself to be under all circumstances a formidable, under favourable circumstances an irresistible arm; but be it said that it has usually fired upon fixed objects, and that when it has been employed on the defensive almost exclusively, as at Belfort, it has been opposed to an enemy incapable of pressing an attack with vigour. The Franco-Prussian war affords us but little information as to the value of the Prussian artillery when attacked by an enemy who will not be denied. This much, however, is certain: that it is more effective on the offensive than on the defensive—in other words, it shoots better at standing than at moving objects.[2]

On the introduction of fire-arms of precision, it was generally assumed that the *rôle* of cavalry during a battle would be confined to engagements with the enemy's cavalry, and that after the battle its proper employment would be the pursuit of the retreating or flying foe. Such was the case in 1866, but 1870 has taught us a different lesson. At the battle of Mars-la-Tour, 16th August, 1870, as the 3rd Army Corps was completely exhausted by a five hours' struggle with an immeasurably superior enemy, and as help could not be expected for another hour, two large bodies of Prussian cavalry were sent to the front, and attacked the French infantry and artillery with terrible vehemence. True, no large mass of infantry was ridden down, and no battery was permanently captured; but the cavalry penetrated into the batteries and through the first and second lines of infantry, swept away everything in the shape of skirmishers and small detached bodies of troops, silenced the guns, and so shattered the *morale* and formations of the enemy that almost a whole hour's delay was gained. The long-looked-for reinforcements had thus time to arrive, and the 3rd Army Corps so far recovered itself as to be able to continue fighting vigorously until late in the evening. The cavalry purchased these great results by equally great losses, but it proved triumphantly that effective charges may still be made against infantry by no means wholly disorganised, and against batteries in action. No doubt the very same infantry and batteries over which this furious cavalry storm burst were able after a time to renew and carry on the fight, and from this point of view the enemy is justified in regarding the charge as a failure; but for a certain time, perhaps a quarter of an hour, or even ten minutes, this cavalry attack absorbed the whole energies of these troops, and their attention was consequently distracted from the rest of the German troops. If this herioc effort be regarded

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[1] It must be borne in mind that the author estimates the extreme range of *effective* infantry fire at 500 paces.—Tr.

[2] I may remind the reader that the truth of this conclusion, in as far as it touches the general question of attack and defence, is disputed by Lieut. Maurice, R.A., in his "Wellington Prize Essay," p. 88.—Tr.

as the extreme of what cavalry can effect during a pitched battle against unbroken infantry and guns in action, it follows that modern cavalry is not capable of achieving permanent successes, even when it attacks several divisions in succession. Such successes can only be accomplished by breaking through and riding down a number of individual battalions, and thus making a practicable breach in the enemy's line of battle; and of this cavalry is still incapable. In order to give permanence to these successes, the cavalry attack must be supported by other troops, especially infantry. I may be allowed to give a general account of the mode in which, in my opinion, such an attack should be made; but in doing so, I wish it to be well understood that I merely describe the salient points of the operation, the details depending entirely on the particular circumstances of each individual case. Let us suppose that a force of the enemy's artillery and infantry, not quite fresh but still quite fit for fighting, have to be attacked by a mass of three to five regiments of our cavalry, the space intervening between the two lines being favourable ground for cavalry—that is, ground over which, notwithstanding some slight obstacles, it is everywhere possible to ride. The cavalry forms for the attack at 3000 paces from the enemy's first line—or in other words, about 1000 paces in rear of its own first line of infantry. In such a position, it is not only far beyond the extreme range of the enemy's infantry, but somewhat beyond the most effective range of his artillery. In front of the cavalry, but in rear of the most advanced infantry—that is, about 2500 paces from the enemy—is posted a body of infantry in lines of battalion columns, the length of this line being somewhat less then that of the cavalry. This body of infantry advances against the enemy at the same moment as the cavalry. The cavalry trots forward through the intervals of the columns, and eventually through and beyond the advanced troops of the first line. Directly the cavalry comes within effective range of the enemy's infantry—say 1000 paces—it sounds the charge.[1] Thus the cavalry is upon the enemy in 9 minutes from the time it moved off, 7 minutes only being required to clear the first 2000 paces at a trot, and 2 minutes the last 1000 paces at the charge. The accompanying infantry, once the cavalry has passed through its intervals, advances as rapidly as is consistent with order; but even though it doubles from time to time, it will not clear the 2500 paces over which it has to pass under 15 minutes. Now, even conceding that the enemy's infantry take the very shortest time possible to reform after the vigorous charge of our cavalry, still they will have scarcely resumed their ordinary fighting formation when our infantry will be upon them This infantry attack the enemy will be hardly able to withstand. His guns will be lost, his infantry will be driven back, and our infantry will establish themselves in his position. This is the moment for our artillery to act. During the successive attacks of the cavalry and infantry, the batteries must be held well in hand, "like greyhounds on the leash,"[2] but the instant the enemy shows signs of wavering, the guns must be slipped and sent forward at full speed, to decide and pronounce the victory by their appearance upon the decisive point at the critical moment. Before this moment ever arrived, however, it is very possible that the cavalry attack,

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[1] "Carriere zum Choc." p. 241.

[2] "Letters during the Peninsular and Waterloo Campaigns," by Sir Augustus Frazer, K.C.B., R.H.A., p. 96.—Tr.

from whatever cause, may have miscarried. It may have been obliged to retire from the horses being blown; it may have been brought to a halt by the enemy's cavalry; it may even have been driven back in confusion. But in any case, the infantry which followed it will give it protection much sooner, and enable it to reform much quicker, than if it had advanced alone; and its losses will thus be much diminished.

There are, no doubt, peculiar dangers in this mode of attack, arising from the infantry following up immediately the attack of the cavalry. The infantry may be ridden down by their own cavalry retreating precipitately in disorder;[1] the infantry themselves may, in the first flush of fight, fire indiscriminately on friend and foe, &c. All this may be true; but it is equally true that without the support of the infantry the cavalry will in all probability fail to gain a decisive success. Hence the question is not whether such a mode of attack entails certain peculiar dangers, but whether it is possible and feasible, and whether the evils that may arise from it are not more than counterbalanced by the happy results it may ensure. There is no royal road to victory; no code of rules has yet been discovered to ensure certain success. War is at an end, indeed, when such a discovery is made. But with bold riders, tough horses, and good infantry, there is no reason why such an attack as I have described should not be made, and carried to a successful termination. Had even two fresh infantry divisions been at hand at Mars-la-Tour, to follow up the cavalry advance and throw themselves on the disordered French, the struggle would have ended at 2.30 p.m. The battle of the 16th would, under such circumstances, have been so complete a victory for the Prussians as to render a battle on the 18th impossible for the French; and the Prussians would have gained the object on the 17th which they only gained on the 19th, after the desperate battle of Gravelotte.

In every war between the great European powers, in addition to the preparatory battles there will be great decisive actions fought between the concentrated forces of both sides; the results of which, though not decisive of the fate of the whole war, will at any rate influence its course to a very great extent, and give a strong colouring to at least one act of the drama. The preparatory battles will be generally fought by fractions of the grand army—fractions so large, however, that a century ago they would have been regarded as armies themselves.

The battles between these fractions of the grand army will have much the same characteristics as the battles of Napoleon's time; in other words, they will be decided by the gradual employment on both sides of all the troops in hand. A corps of 30,000 men, occupying a position in which its front is searched by a single gun of the enemy, or by two good shots armed with Chassepots, can easily be withdrawn, by movements suitable to the configuration of the ground, to another position favourable to it in the highest degree; but no expedient can be devised to prevent the enemy, if he chooses it, from bringing his last man under fire.

The characteristics of the grand battles of the present day will probably be quite different from this. Owing to the great precision and deadliness of

[1] Infantry, under such circumstances, would do well to copy the rough and ready way in which, during one of our Peninsular battles, the 29th Regiment, advancing in line to the attack, cleared its front of some Spanish regiments who were flying before the victorious French.—Tr.

fire-arms, battles have again essentially become mighty duels, fought by hosts of men armed with breech loaders, and drawn up in some form of the line formation.[1] These lines, no doubt, are long flexible chains, every link of which is "a living organism,"[2] not a rigid bar, as formerly; but no single link of the chain can be broken at a decisive point without serious consequences. Should such a link be definitely broken by the attacker, he will command from this point by his far-reaching fire so great an extent of the enemy's line that the defender will only have the alternative of retreat or surrender. Battles of the present day, therefore, resemble those of Frederick the Great's time in this—that a local victory at one point may decide the day, and that fighting along the whole line and with the whole of the forces may not be necessary. On the other hand, the organisation of armies is now such as will enable them to dole out, gradually and from time to time, fuel for the fight, without greater inconvenience—perhaps with greater facility—than in Napoleon's time. To the battles of his time, battles of the present day still bear this strong resemblance—that no decisive result takes place until the last man who can be brought up is thrust into the fight at the decisive point.

Since the improvement in fire-arms, two grand decisive battles have been fought—Königgrätz and Gravelotte.

At Königgrätz the characteristics above mentioned were markedly exhibited. The first position of the Austrians became untenable as soon as Chlum and its neighbourhood fell definitely into the hands of the enemy; this decisive result being almost exclusively brought about by the fighting around Chlum. Along the whole of the rest of the line of battle, occupied by the 1st Prussian army, only an artillery duel was carried on, and three-fourths of this army contributed to the victory solely by its presence. After the capture of Chlum, the Austrians retired to a second position—that originally occupied by their reserves; but this in its turn was rendered so untenable by the taking of Problus by the army of Elbe, that it had to be given up at all other points. This second great result was also gained by comparatively few troops. A third position was impossible for the Austrians, owing to the nature of the ground, and their *morale* was so lowered that for the moment[3] they were wholly unfit for further fighting, although not more than two-thirds of their force had been engaged.

Not so clear at first sight, but quite perceptible on closer examination, are these same characteristics in the second grand decisive battle of our time—Gravelotte. The German commander resolved at all hazards to drive back the French upon Metz; while Marshal Bazaine was bound to hold fast to the only line of communication with the rest of France that still lay open to him.

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[1] In justice to the author, I am bound to confess that the long-winded periphrasis in the text is due to my inability to translate in fewer words the term "Linien-Feuergefecht." p. 244.—Tr.

[2] Lieut. Maurice's "Wellington Prize Essay," p. 33.—Tr.

[3] "Momentan." p. 245. Colonel Stoffel, after describing certain circumstances which happened after Königgrätz, insists that the demoralisation of the Austrians was of a far more serious and permanent nature than is suggested by the word "momentan." "De pareils faits ne sauraient être attribués uniquement à la démoralisation qu' engendrent de grands désastres militaires; ils révèlent un abaissement des caractères et une véritable décadence morale." See the dispatch, "L'Autriche est-elle en décadence?" in his "Rapports Militaires," p. 44.—Tr.

The decisive point of the position,[1] therefore, was S. Privat, on the extreme French right, by which this last line of communications ran. As the fate of the whole battle naturally turned upon the course taken by events at S. Privat, the desperate fighting and frightful slaughter that took place along the rest of the line was wholly unnecessary, and was wilfully brought on by the assailants, rather than caused by irresistible necessity.[2]

The great battles of the present day, then, are as it were a mean between those of Frederick the Great and of Napoleon. In common with the first, they afford the possibility of winning a complete victory by gaining a decisive success at a single point. In common with the second, they are marked by the peculiarity that success is only possible at any point by bringing up successively to that point every available man.

From the characteristics of modern battles, their general course can be readily ascertained. Either, one of the two armies determines on fighting defensively, and takes up a more or less well selected position, on which it offers a *rendezvous* to the other army—as at Königgrätz, Wörth, Gravelotte, and Belfort; or both armies move towards some battle-field, eventually selected rather by chance than by choice—as at Mars-la-Tour and Sedan. In both cases the general tenor of events will be much the same; for even in the latter of the two, one army will generally act on the defensive, the other on the offensive. However matters turn out, both armies must make up their minds for a battle. Contrary to former usage, the best mode of determining now whether the enemy is willing to accept battle, is to advance without delay a considerable force of artillery, which from its great range and destructive effect can scarcely ever be left unnoticed, and which thus forces the enemy at least to show the whole extent of his front. Whilst the rest of his army developes itself behind the batteries, an opportunity is afforded of reconnoitring his position sufficiently for all practical purposes, and of fixing the points which are easiest to attack and most desirable to possess. Such decisive points there always are, and in general it is not very difficult to find them; their position depending first on the nature of the ground, and secondly on strategic considerations. Thus at Wörth, at Mars-la-Tour, and at Gravelotte, the decisive point, on the seizure of which victory depended,

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[1] "It is a curious fact," says Lieut. Maurice, R.A., (Wellington Prize Essay, p. 12, *note*), "that on almost the only point on which Capt. May and Col. Schellendorf were agreed—the disappearance of key positions on battle-fields—the German general" (the present author) "differs from both of them. 'Who shall decide when' such 'critics disagree.'"—Tr.

[2] Major-Gen. Lord Mark Ker's explanation of the Prussian tactics at Gravelotte is so thoroughly original as to deserve notice:—"I believe the turning of the French right to have been a 'pensée de l'escalier.' The Germans had retired—had certainly ceased to advance for some time—when it was discovered that the French right, though it kept its ground, was without ammunition; and Canrobert, who commanded it, was obliged to retire in his turn. The German tactics were as bad at S. Privat as they were all throughout the war against the French imperial army. With overpowering numbers they employed the column covered by swarms of devoted skirmishers, and they attacked in front. These tactics were changed later."—"Journal of the Royal United Service Institution," Vol. XVI., No. 67, p. 239.

If the German commander's original intention was a front attack, no doubt the flank attack on S. Privat was a "pensée de l'escalier;" but I agree with my author that the flank attack on S. Privat was deliberately planned beforehand; that the desperate fighting "along the rest of the line" was an accident; and that such a notion as a front attack never crossed von Moltke's mind. These questions, however, offer a fair field for fight.—Tr.

lay on the French right; at Sedan it was reached by debouching at Donchery, between Floing and Fleigneux; at Belfort it was to be found at every accessible point along the long German line of battle, but especially on their right at Frahier.

The point of attack once selected, the preparation for the attack begins. That part of our position which lies directly opposite the decisive point should be left as open as possible for the movements of the troops that may have to attack; but on both sides of this free space as many batteries as possible should be brought into action—first, to silence the fire of the enemy's guns posted near the point of attack by an overwhelming fire; secondly, to destroy everything in the way of cover in the neighbourhood of the same point; and thirdly, to throw the enemy's troops into serious disorder. At this stage of the action, the artillery of the attack is far more effective than that of the defence. The former has the enemy's artillery, the objects covering it—such as villages &c.—and finally the enemy's troops to fire at, while the latter has nothing but artillery as a target. If the assailant succeeds in bringing into action, were it only for a moment and at one point, an overwhelming mass of artillery, he may in no long time have succeeded in thoroughly preparing the attack. He must beware, however, of committing an error of judgment—a mistake at this crisis may be fatal; and he should bear in mind that it is far better to cannonade the enemy too long than too short a time. The attack itself may be purely an infantry one; or if the ground and the position of the enemy admit of it, a cavalry attack well supported by infantry. In order to ensure the result, there must invariably be a proportionally strong body of troops ready to follow in the footsteps of the columns of attack, and to fasten with an iron grip upon the position from which they may have driven the enemy. It is self-evident that a sufficient number of guns also must be ready to advance and occupy the point of attack, in case it be carried; but in no case must these guns be taken from those which prepared the way for the attack. Those guns will retain their position, and will not remain long unoccupied if the defence be vigorously maintained.

The defender has long before this learned, from the increased firing, the point in his line which the enemy has selected for attack; and then arises the question—ought this point to be strengthened by artillery? In general, it is impossible to answer this question definitely, in one way or other. The effect of artillery is less, no doubt, against troops on the move than at the halt; but it is always great, and a reinforcement of artillery will always produce a result proportionate to its strength. But if the defender has no great superiority, or is very much inferior in the number of his guns, he can do much better with his reserve artillery than advance it into the first line. Far from doing so, he should place it as far as possible out of the range of the assailant's guns, behind the point of attack, so as to be able to bring a murderous fire to bear on that point if it be carried. The most perfect weapon of defence is the breech-loading rifle. Infantry almost hidden from view by irregularities of ground, can with the greatest ease vary their range according to the varying distance of the enemy, by merely making a proper use of the sights of their rifles; and the destruction done by their good shots is so great, in consequence of the rapidity of fire of the breech-loader, that one hundred cool, self-possessed men have withstood before now the attacks of ten times their number. The point of attack, then, should be strengthened

by infantry, in case the defender has any to spare, and can keep them to some extent, although in a loose formation, covered from the fire of the enemy's artillery. In case the attack succeeds, such a force of fresh infantry—and if the ground is favourable, of cavalry also—must be kept in hand, behind the reserve artillery, as can in turn assail the assailant with good prospect of success; their advance to recover the lost position being duly prepared by a rapid fire of the guns. This counter-attack has many chances in its favour; for in the heat and hurry of the attack, a number of gaps are sure to be left in the assailant's line, and from his ignorance of the nature of the ground, he will hardly succeed in taking full advantage of the cover it affords. To meet the defender's counter-attack, the assailant brings up his reserve; and thus Victory hovers—now over the one, now over the other—until at last, one side having completely exhausted all the troops disposable at this point of the line of battle, she finally inclines to the other side which brings up the last reserve. The struggle at Bazeilles, during the battle of Sedan, is a good illustration of this alternate ebb and flow of victory; but it should be added that the position was by no means a decisive one, and its possession was not of sufficient importance to exercise an essential influence over the general battle. On the contrary, its capture brought the victor but very doubtful advantage, while its loss offered little hindrance to the conquered to continue the fight.

From the great length of the line of battle in the gigantic warfare of modern times, it is self-evident that several decisive points may lie along the front on both sides; and that consequently one may be acting offensively at one part and defensively at another part of the battle-field, at the same moment. Further, at no point is an absolute cessation from hostilities possible; at no point can the battle be suffered to dwindle away even into an indecisive cannonade. Fighting must so far be kept up along the whole line as to pin the enemy to his position and keep him engaged; but decisive struggles need not be sought for everywhere, nor is the successive employment of all the available forces at every point in any way required. If, like the Prussians and Austrians at Leuthen, the numerical difference between two armies of equal quality is so small as to render a decisive victory seemingly hopeless, still let it be steadily borne in mind that the clearly developed peculiarities of modern battles render it far easier than in Napoleon's time for the lesser number, if well led, to attack the greater with a prospect of success.

It will not be out of place here to give some account of a battle of the late war in which the challenge offered by one army in a position carefully and deliberately chosen beforehand, was willingly accepted by the other—I mean the battle of Gavelotte.[1]

I have already stated that S. Privat was *par excellence* the decisive point of the battle-field; but this statement requires further explanation. The position of the French army, from its left which rested on the heights overlooking the Moselle, followed the crest of a line of commanding heights which, passing through several farms and the villages of Amanvillers and S. Privat, stretched away in a north-westerly direction until they sank into the valley of the Orne. Behind their left, from the extreme flank to the farm

[1] The best map of Gravelotte I have seen is that in Col. Fay's "Journal d'un Officier, &c."—Tr.

of Leipsig, 2500 paces south of Amanvillers,[1] lay forts S. Quentin and Plappeville—outworks of the fortifications of Metz.[2] In prolongation of the right flank ran the single road which served to maintain communications between the French army and the rest of France. As long as his right held fast, Marshal Bazaine's freedom of movement was by no means circumscribed. Indeed S. Privat was so commanding a position, that while it was occupied by the French no attack on their centre at Amanvillers could be made with a hope of success.

The object of the German commander, on the other hand—as was clearly proved by the battle of Mars-la-Tour—was to drive the French into Metz; and the point of attack was evidently S. Privat, on the capture of which the accomplishment of this object essentially depended.

It behoved both sides, therefore, to strain every nerve to capture S. Privat; for fighting at any other point of the position, though it might be bloody, could not possibly be so decisive as here, and in fact such fighting would be absolutely without result for the Germans. An attack on the French left, even if completely successful, could only be pushed by the victors to the confines of the space swept by the guns of S. Quentin and Plappeville. So far could they go, but no further. To break the centre at Amanvillers might certainly lead to a ruinous division of the French army; but to do so was difficult, if not impossible. In the first place, there was no good position within effective range of Amanvillers from which the German artillery could prepare the attack; and in the second place, Amanvillers was commanded by S. Privat and flanked by Leipsig. Finally, such an attack, though perhaps possible, would have been unprofitable; for the French would be obliged voluntarily to evacuate Amanvillers as soon as S. Privat was captured. The Germans, therefore, had only to engage the enemy along the rest of the line to such an extent as was necessary to pin him to his position and observe his movements. Against S. Privat and its neighbourhood only, had a regular attack to be made.

It may be said that, by a victorious advance of his left wing, Marshal Bazaine might have given a turn to the battle that would have been ruinous to the Germans. But let it be remembered that the German right occupied a splendid position on the heights of Gravelotte, and that the result of the previous battles of the war was not such as to justify the Marshal in building upon the success of an attack against his enemy when well posted and in force. Only, indeed, after the German wave of battle had surged and dashed against the heights on which the French were posted until it was broken and driven back, could such an advance be thought of. That some such idea may have occurred to the Marshal, however, is probable from the great strength of this wing,[3] and the position of the reserve at Plappeville. The uselessness of success, and the dangers that might arise from failure, ought

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[1] On Col. Fay's map I make this distance 3700 yds.—Tr.

[2] Measured on Col. Fay's map, Fort S. Quentin is 4000 yds. from Jussy, where the extreme French left rested, while Fort Plappeville is 4800 yds. from Leipsig. I may remark that "schritt" is the German word which I translate into the English "pace."—Tr.

[3] A French officer maintains that the preponderance of the French troops was just the other way. Describing the French right, he says, "le Maréchal y avait placé énormément de troupes."—"La Campagne de 1870, jusqu' au 1re Sept." p. 68.—Tr.

certainly to have restrained the Germans from the desperate attack which they eventually made upon this part of the French position—an attack in which the number of lives wantonly sacrificed in the 7th and 8th Corps must have equalled the loss of the 2nd and 3rd Corps of the 1st army at Königgrätz.

A successful advance of the French from the direction of Amanvillers would have been fraught with far less danger to the Germans. The position occupied by the Germans opposite this village was unquestionably harder to defend than that of Gravelotte; but the ground was so close and so irregular that a general view of it was impossible, and the numerical superiority of the Germans was so great, that by a flank attack they might have involved the French in an irretrievable catastrophe. But there was no reason to fear a French attack on this point. Far from having leisure to deliver an attack, they were actively engaged in repulsing one which the Germans had made on them in force. This attack was wholly unnecessary; but it fettered and absorbed a large body of the enemy's troops who would otherwise have been available for the fight that raged round the decisive point, S. Privat. The attack of the Germans at this point had much the same effect on the general result of the battle at Gravelotte, as the fight of the 7th division in the forest of Maslowed on the capture of Chlum at Königgrätz.

Of all the evils that might befall the Germans, the least to be dreaded was a French success at S. Privat; for if the first Prussian troops were repulsed, the attack could be renewed by the supports, reinforced if necessary by the reserves.[1] On the other hand, if the Germans succeeded in occupying S. Privat, no power under heaven could prevent them from accomplishing their design of forcing back the great French army upon the fortifications of Metz. I say, then, that S. Privat was *par excellence* the decisive point of the battle-field.

Against S. Privat, therefore, was rightly directed the main attack of the Germans, which was intrusted to two intact army-corps—the Guards and the 12th. To this attack I shall now confine myself, neglecting the capture of the outpost, S. Marie-aux-Chenes.

It is needless to expatiate upon the self-evident principle that the fewer the guns available to prepare the way of the attack, the longer they will take to effect the desired end. Now, the first attack against S. Privat was preluded only by the fire of the greatest part of the guns of the Prussian Guards. It is doubtful whether it was at all possible, with so few guns, to prepare thoroughly the way for an attack against so strong a position; it is certain that this could only be done by a prolonged and deliberate cannonade. But no time was allowed the artillery for such a cannonade. Ere half the gunners' heavy task was done, the devoted Guards went forward to the attack, and the result was frightful slaughter and a decided repulse. Time ran on. The artillery of the 12th Corps took up a commanding position on the extreme German left; the reserve artillery of the 3rd Corps was brought up to the front; the French position was cannonaded for more than an hour by

[1] The failure of the first Prussian attack against S. Privat was due to two causes: first, the advance of the Guards before the artillery had had time to prepare the attack properly; secondly, the company column formation adopted by the Guards. On this latter point, see Lieut. Maurice's Essay, p. 28, *et seq.*—Tr.

over 200 guns; and about 7 o'clock p.m. S. Privat was stormed and won by the Prussians with little loss.[1]

On the French side, Marshal Canrobert, who commanded at this point, had early withdrawn his guns from the overwhelming fire of the Prussian artillery, and placed them in a position further to the rear, on the confines of the forests of Saulny and Jaumont, from which they could effectively cannonade S. Privat. With the guns he probably sent a force of infantry as escort, and thus weakened the defence of the decisive point of the field. Immediately after the capture of S. Privat, this artillery opened a terrible fire upon the Germans, as a preparation for the counter-attack; but the Marshal was too weak to attempt it. The division of the Imperial Guard, which Marshal Bazaine hurried up from the reserve at Plappeville, only arrived in time to find the Germans firmly established in and around S. Privat; and further offensive operations were rendered almost impossible by the darkness which was now rapidly closing over the battle-field. Had the Guards been pushed up without delay when it first became unmistakeably evident that S. Privat was the cardinal point of attack, they would certainly have come into position long before the second German attack; and by recapturing S. Privat in a counter-attack, they might have so far re-established the fortunes of the French as to render Gravelotte a drawn battle.

Thus fell S. Privat. By its fall Amanvillers became untenable; the desperate fighting along the rest of the line had been indecisive; and the battle was definitely lost to the French.

Newport, Monmouthshire,
17th Sept., 1872.

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[1] There are two, and only two, facts bearing upon the attack on S. Privat which have not been, and cannot be contested. The first is, that the first Prussian attack failed; the second is, that the second Prussian attack succeeded. I have already explained the two causes to which I believe the failure of the first attack was due. It is idle to speculate on the causes that led to the success of the second, for before it was made the French had run short of ammunition. Whether the French would have repulsed the second attack had they been properly supplied with ammunition, is a question that lies within the confines of the unknown.—Tr.

GENERAL ABSTRACT

OF THE

INCOME AND EXPENDITURE OF THE ROYAL ARTILLERY INSTITUTION,

From 1*st April*, 1872, *to* 31*st March*, 1873.

EXPENDITURE.

		£	s.	d.	£	s.	d.
Printing	Wages	144	17	0	487	10	6
	Paper	247	1	1			
	Type and Materials	26	9	11			
	Woodcuts	46	4	6			
	Lithography	22	18	0			
R.A.I. Prize Essay					10	10	0
Chemistry					0	2	4
Photography	Salary	94	0	0	243	17	3
	Photographic Prints	149	17	3			
Classes	Drawing	54	17	6	63	5	6
	Italian	0	0	0			
	Mathematics	8	8	0			
Lectures					4	2	0
Taxidermy					4	14	0
Library, and Books for Sale					294	12	3
Museum					39	2	0
Instruments					288	15	0
Carpenter	Wages	18	5	2	92	19	10
	Materials	74	14	8			
Furniture and Repairs					11	9	9
Subscriptions	To Societies	5	5	0	6	1	0
	Refunded	0	16	0			
Stationery					203	9	1
Postage and Parcels					50	10	5½
Incidental					52	15	6½
Wages to Clerks and Orderlies					140	3	5
War Office Photographs and Lithographs					35	12	5
Premium for Fire Insurance,	£5000	12	10	0	14	1	3
	£1000	1	11	3			
Cash in hand, 31st March, 1873,	Secretary	56	7	2	96	1	6
	Messrs. Cox & Co.	39	14	4			
					£2139	15	1

INCOME.

		£	s.	d.	£	s.	d.
Cash in hand, 31st March, 1872					23	17	2
Printing					220	8	6
R.A.I. Prize Essay					10	10	0
Chemistry					0	5	6
Photography					224	9	3
Classes	Drawing	35	5	9	43	4	5
	Italian	2	6	8			
	Mathematics	5	12	0			
Lectures					0	0	0
Taxidermy					4	14	6
Books sold					203	18	1
Museum					0	0	0
Instruments					4	19	0
Carpentry and Wood					46	18	5
Furniture and Repairs					0	0	0
Subscriptions	Entrance	66	0	0	1119	5	0
	1867–8	0	16	0			
	1868–9	1	6	0			
	1869–70	1	16	0			
	1870–1	2	16	0			
	1871–2	15	6	0			
	1872–3	1022	17	6			
	In Advance	8	7	6			
Stationery					127	0	4
Postage and Parcels					29	2	9
Incidental					0	19	0
War Office Photographs and Lithographs					30	8	4
Dividends on £1686 5s. 7d. Consols					49	14	10
					£2139	15	1

DEBTOR AND CREDITOR ACCOUNT, 31st MARCH, 1873.

Dr.

	£	s.	d.
Mr. J. Gould, for "Birds of Australia"	70	15	0
Mr. Howard Grubb, for Telescope	276	0	0
Printing Paper, Wood Engraving, &c.	6	1	10
Drawing Instruction	28	17	6
Photography	16	8	9
Books	15	19	8
Carpentry, Wood, &c.	5	5	11
Stationery	5	13	8
Incidental	0	7	2
Balance Creditor	1893	6	9
	£2318	16	3

Cr.

		£	s.	d.	£	s.	d.
Balance Cr.	Cash in hand	96	1	6	1647	9	0
	Consols Stock (at 92)	1551	7	6			
Value of Stock.	Books for Sale	20	8	6	316	8	9
	Stationery	41	15	0			
	Printing Paper	38	10	5			
	"Handbooks" (unbound)	88	18	1			
	"Kane's Lists" do.	106	16	9			
	Chemicals in Laboratory	20	0	0			
Owing by Members and others for	Printing	38	0	7	354	18	6
	Chemistry	0	4	2			
	Photography	45	14	2			
	Classes	9	1	0			
	Taxidermy	4	19	6			
	Books	55	14	1			
	Carpentry and Wood	7	16	5			
	Annual Subscriptions	66	9	6			
	Stationery	93	11	1			
	Postage	24	18	3			
	War Office Photographs and Lithographs	8	9	9			
					£2318	16	3

Examined and found correct,

S. E. GORDON, Lt.-Col. R.A., & Col., President Sub-Committee.

WOOLWICH, May 7th, 1873.

W. H. KING-HARMAN, Capt. R.A., Secretary and Treasurer.

Y INSTITUTION,

INCOME.

	£	s.	d.	£	s.	d.
				23	17	2
				220	8	6
				10	10	0
Printing				0	5	6
				224	9	3
	35	5	9			
R.A.I. P:	2	6	8	43	4	5
Chemistr	5	12	0			
Photogra				0	0	0
				4	14	6
				203	18	1
Classes				0	0	0
				4	19	0
Lectures				46	18	5
Taxiderm				0	0	0
Library,	66	0	0			
Museum	0	16	0			
Instrume	1	6	0			
Carpente	1	16	0	1119	5	0
	2	16	0			
Furnitur	15	6	0			
Subscript	1022	17	6			
	8	7	6			
Stationer				127	0	4
Postage				29	2	9
Incident				0	19	0
Wages tchographs				30	8	4
War Offiols				49	14	10
Premium						
Cash ir 31st Mar						
				£2139	15	1

DR. CR.

	£	s.	d.	£	s.	d.
	96	1	6	1647	9	0
2)	1551	7	6			
Mr. J. G	20	8	6			
Mr. Hov	41	15	0			
Printing	38	10	5			
Drawing bound)	88	18	1	316	8	9
Photogr do.	106	16	9			
Books atory	20	0	0			
Carpent	38	0	7			
Statione	0	4	2			
Incident	45	14	2			
	9	1	0			
	4	19	6			
	55	14	1	354	18	6
d	7	16	5			
ns	66	9	6			
Balance	93	11	1			
	24	18	3			
aphs and Lithographs...	8	9	9			
				£2318	16	3

S. E. (AN, Capt. R.A., Secretary and Treasurer.

ANNUAL REPORT

AND

ABSTRACT OF PROCEEDINGS OF A GENERAL MEETING OF THE ROYAL ARTILLERY INSTITUTION, HELD ON JUNE 2, 1873.

COLONEL J. W. DOMVILLE, R.A., IN THE CHAIR.

1. The Committee of the Royal Artillery Institution has the honour to present to the Annual General Meeting its Report and the Abstract of Accounts for the year ending 31st March, 1873.

It will be seen by the accompanying table that during the past year 74 officers have joined the Institution; and that, after allowing for casualties caused by death, withdrawals, &c., there is a net increase of 8 members.

Circulars have been sent to all members who have retired during the past year, inviting them to submit their names for re-election, in accordance with the rules. The greater number have done so, and have been re-elected, some have not yet been heard from, and a few have withdrawn.

Rank.	31st March, 1872.	Additions.				Total additions.	Deductions.						Total deductions.	31st March, 1873.
		Promotion.	Retirement.	From retired list.	New members.		Promotion.	Retirement.	To effective list.	Resignation.	Withdrawal.	Deaths.		
EFFECTIVE LIST.														
General and Regimental Field Officers	209	257	—	—	7	264	—	24	—	—	18	6	48	425
Captains	463	59	—	3	9	71	257	3	—	1	1	3	265	269
Lieutenants	487	—	—	1	46	47	59	3	—	2	3	5	72	462
Paymasters	7	—	—	—	1	1	—	—	—	—	—	—	—	8
Quarter-Masters	7	—	—	—	1	1	—	—	—	—	1	1	2	6
Riding-Masters	6	—	—	—	—	—	—	—	—	—	—	—	—	6
Surgeons-Major	8	—	—	—	—	—	—	—	—	—	3	1	4	4
Surgeons	1	17	—	—	1	18	—	—	—	—	6	—	6	13
Assistant-Surgeons	17	—	—	—	—	—	17	—	—	—	—	—	17	0
Veterinary Surgeons	4	—	—	—	—	—	—	—	—	—	—	—	—	4
RETIRED LIST.														
General and Regimental Field Officers	64	—	24	—	2	26	—	—	—	—	2	4	6	84
Captains	45	—	3	—	2	5	—	—	3	—	5	—	8	42
Lieutenants	8	—	3	—	1	4	—	—	1	—	—	—	1	11
Surgeons-Major	2	—	—	—	—	—	—	—	—	—	—	—	—	2
Surgeons	0	1	—	—	—	1	—	—	—	—	—	—	—	1
Assistant-Surgeons	1	—	—	—	—	—	1	—	—	—	—	—	1	0
Veterinary Surgeons	0	—	—	—	1	1	—	—	—	—	—	—	—	1
Chaplain	1	—	—	—	—	—	—	—	—	—	—	—	—	1
Honorary Members	47	—	—	—	3	3	—	—	—	—	4	—	4	46
Totals	1377	334	30	4	74	442	334	30	4	3	43	20	434	1385

2. The Committee is glad to inform the meeting that the financial condition of the Institution is most satisfactory, the accounts showing a balance credit of £1893 6s. 9d., against £2096 2s. 4d. last year, while the disbursements have been unusually large.

3. *Printing and Publication.*—Three numbers of Vol. VIII. of the "Proceedings" have been published during the last year, containing:—

Tables of Remaining Velocity, Time of Flight, and Energy of various Projectiles, calculated from the results of experiments made with the Bashforth Chronograph, 1865–1870. By the Rev. F. Bashforth, B.D., Professor of Applied Mathematics to the Advanced Class, Royal Artillery.

Notes extracted from some German Pamphlets on the Employment of Artillery in the Field. By Captain W. G. Brancker, R.A.

The Study of Natural History. A Lecture delivered at the R.A. Institution, Woolwich, October 3, 1871, by Canon Kingsley.

The Use of Railroads in Time of War. Communicated by Major-General Sir David Wood, K.C.B.

The Bavarian "Revolver-Cannon." By Captain E. Baring, R.A.

Remarks on the Proper Proportion of Guns to Men. By Captain E. Baring, R.A.

A Short Sketch of the Rhine Fortresses and Metz. By Lieut. F. W. J. Barker, R.A.

Autumn Manœuvres; considered in their Place between Drills and War. A Lecture delivered at the R.A. Institution, Woolwich, December 19, 1871, by Captain C. B. Brackenbury, R.A.

"Kriegs Spiel" or "Game of War." By Captain F. C. H. Clarke, R.A.

Flat Trajectories: What are They? Exemplified in the case of Small-Arms and Field Artillery. A Paper read at the R.A. Institution, Woolwich, February 29, 1872, by Captain J. Sladen, R.A.

Annual Report and Abstract of Proceedings of a General Meeting of the Royal Artillery Institution, held on May 28, 1872. Colonel J. W. Domville, R.A., in the Chair.

The Establishment and Organisation of an Arsenal. By Lieut. E. H. H. Collen, R.A. The R.A. Institution Prize Essay of 1872.

Sketches of Artillery and Infantry Attack and Defence (after the German), and a Note on Infantry Column and Line. By Lieut.-Colonel W. J. Williams, R.A.

Précis of Report of Colonel Baron Henri Berge, of the French Artillery, upon the British 9-pr. M.L. Gun. By Lieut.-Colonel W. E. M. Reilly, C.B., R.A.

Artillery Lessons from the Siege of Strasburg, 1870. By Captain F. C. H. Clarke, R.A.

The Development of Artillery Tactics in Combination with the other Arms. A Lecture delivered at the Prince Consort's Library, Aldershot, on the 27th March, 1872, by Captain Fox Strangways, R.H.A.

The Range-Finder. By Captain Nolan, R.A.

The Mobility of Field Artillery; Past and Present. By Captain Hime, R.A.

The Spontaneous Ignition of Oiled Cotton or Silk-Waste. Contributed by Major V. D. Majendie, R.A.

Notes on Curved Fire. Submitted by Col. S. E. Gordon, C.B.

The following "Short Notes" have also been published:—

Table giving the calculated remaining Velocity and Energy, at various distances, of projectiles fired from the service M.L.R. guns with battering charges of P. powder.

Table showing the mean muzzle velocity of projectiles fired from the service rifled guns.

"Die Kartätschgeschütze."

A proposed Plan for Carrying the Detachments with Field Artillery.

"Occasional Papers of the R.A. Institution."

"Rough Rules for Gunners."

List of Service Ordnance and Ammunition.

Description of a Dummy Time Fuze. Communicated by Captain H. D. Evans, R.A.

Table giving the calculated remaining Velocity and Energy, at various distances, of Palliser Projectiles fired with battering charges of P. powder, from the 12-in. Rifled M.L. Gun of 35 tons. Communicated by Captain W. H. Noble, R.A.

Abstract shewing the Pressures observed from time to time during practice at Shoeburyness with the 12-in. Rifled M.L. Gun of 25 tons, Expl. No. 372. Communicated by Captain W. H. Noble, R.A.

German 8½-in. Gun. Communicated by Lieut.-Colonel W. E. M. Reilly, C.B., R.A.

Account of the Bursting of an 11-in. cast-steel Krupp Gun, at Cronstadt, on Sept. 29, 1871. Communicated by Lieut. F. E. B. Loraine, R.H.A.

Several very interesting "Translations" have been issued during the past year, and the thanks of the Royal Artillery Institution are due to Captain F. C. H. Clarke, R.A., Lt.-Col. W. H. Goodenough, R.A., Captain H. W. L. Hime, R.A., and Lieuts. Crawford and D. F. Jones, R.A., for the trouble they have taken to procure subjects which they considered worth the attention of their brother officers, and the skill with which they have translated these subjects; also to Lt.-Col. W. E. M. Reilly, C.B., R.A., who has communicated several articles of an interesting character.

List of "Translations" published during the year.

Austrian and Prussian Notions on Practical Field Gunnery. Translated by Lieuts. H. R. G. Craufurd and H. W. L. Hime, R.A.

A Review of Captain Von Doppelmair's Pamphlet on the "Prussian Heavy Cast-Steel Breech-Loading Guns and the 9-inch Woolwich Gun," by Captain Monfroni. Translated by Lieut. D. F. Jones, R.A.

The Separation of the Artillery: the Field Artillery as a part of an Army Division, and the Independence of the Garrison Artillery. By O. & M. Translated from the German by Captain F. C. H. Clarke, R.A.

I. R. Austrian Artillery Field Exercise: Parts III. & VII. Translated by Lieut.-Colonel W. H. Goodenough, R.A.

On Sieges. By Kraft, Prince of Hohenlohe-Ingelfingen, Maj.-General, Inspector of the 2nd Artillery Inspection. Translated from the German by Captain F. C. H. Clarke, R.A., Topographical Staff.

The "List of Service Ordnance and Ammunition" was corrected up to the 1st October, 1872, and a fresh issue made. It has since been corrected up to the 31st March, 1873, and the Committee begs to thank the officers in the Royal Arsenal who have assisted in this matter.

With reference to the prize essay for this year, eleven essays were received, and on the 17th April they were submitted to Major-General E. M. Boxer, F.R.S., Lieut.-Colonel C. H. Owen, R.A., and Captain J. Sladen, R.A., who kindly consented to act as referees, the result of whose decisions is that the medal for this year is awarded to Lieut. E. Clayton, R.A.

4. *Library.*—The Committee regrets that in consequence of changes of Secretary, and unavoidable press of work caused by the erection of the telescope, and other causes, the catalogue promised last year is not yet in the hands of members. It is hoped that it will soon be ready for issue.

The following is a list of presentations to the Institution during the year:—

Books, &c., presented.

From Sedan to Saarbruck. By an Artillery Officer	The Author, Lieut. Knollys, R.A.
Reports of the Examination for admission to the Staff College; held July and December, 1870, July and December, 1871, and July and December, 1872	The Director-General of Military Education.
Hasty Entrenchments. By A. Brialmont, Col. on the Belgian Staff. Translated from the French by Lieut. C. A. Empson, R.A.	The Translator.
The Birds of the Færoe Islands. By Captain H. W. Feilden, 4th Regt.	The Author.
Two Photographs of a Raft, with 12-pr. Gun and Carriage, sailing across the River St. Lawrence, from Montreal to St. Helen's Island.	Lieut. Short, "B" Battery, School of Gunnery.
Album of Photographs, containing 54 Views of American Scenery, and 3 Reminiscences of the late Franco-Prussian Campaign	Lieut. J. D. Legard, R.H.A.
Two Photographs of an Ornament of Unalloyed Gold, weighing 1½ lbs. Troy, dug up by a Sapper, while at work on a siege battery. Supposed by eminent authority to belong to a period anterior to the first Roman invasion of Britain, B.C. 55	Colonel T. L. J. Gallwey, R.E.
Austrian Artillery and Engineer Journal for 1870 & 71, in 2 vols., and 2 vols. of Plates to accompany same; and Parts I. & II. for 1872	Austrian Government.
Rifled Cast-Iron Ordnance. By Bashley Britten. On the Construction of Heavy Artillery. By Bashley Britten	The Author.
Proceedings of the Institution of Mechanical Engineers, January 72, May 72, July 72	The Council of the Institution.
Journal of the Royal United Service Institution, Vol. XV. No. 65, and Vol. XVI. Nos. 66, 67, 68, & 69 State of Portugal, 1827 A Collection of Regulations for the Army, 1807	The Council of the Royal United Service Institution.
Proceedings of the Scientific Meetings of the Zoological Society of London, 1871, Parts II. & III.; and 1872, Parts I. & II. Catalogue of the Society, 1872 Index, from 1861 to 1870 Revised List of the Vertebrated Animals now or lately living in the Gardens of the Zoological Society of London. 1872	The Council of the Society.

Text Book of the Construction and Manufacture of Rifled Ordnance	
Committee on High Angle and Vertical Fire from Rifled Howitzers and Mortars, and on M.L.R.Guns of Large Calibre for Field Service. Reports III. & IV.	
Report by the Director-General of Education upon the Fourth Advanced Class of Royal Artillery Officers	
The Supply of Ammunition to an Army in the Field	
Military Reports addressed to the French War Minister by Colonel Baron Stoffel, French Military Attaché, Berlin. Translated by Captain Home, R.E.....................................	
Memorandum on the German Army. By General Beauchamp Walker, C.B.........................	
3 Maps:—	
One-inch Map, shewing Line of Route; one copy of Camping Grounds; and one copy shewing Salisbury, and Vicinity of Autumn Manœuvres 1872	
Report of the Special Committee on Gun-Cotton, &c.	
On the Storage and Transport of Gun-Cotton ...	
Description of the Moncrieff Carriage, Pattern I., for 7-in. M.L.R. Guns	The Secretary of State for War.
Progress Report of the Committee on Explosive Substances, with Selections from Appendices...	
60 W.O. Photographs	
4 R.G. Factory Lithographs..........................	
Campaign in Germany, 1866, with 22 Plans in covers	
Notes on Ammunition, 1872. By Captain W. R. Barlow, R.A.	
The Franco-German War. First Part, Second Section. Translated by Captain F. C. H. Clarke, R.A..	
Six copies each of Nos. I., II., & III., Vol. X. of Extracts from the Proceedings of the Department of Director of Artillery	
Reforms in the French Army. Part I. The Law of Recruiting. Translated by Captain Home, R.E.	
The Armed Strength of Russia. Translated from the German	
Notes on a Visit to Berlin. By Lieut.-Colonel E. Reilly, C.B., R.A., Assistant Director of Artillery	
Report on the Crimean Cemeteries. By Brig.-General J. M. Adye, C.B., and Colonel C. G. Gordon, C.B., R.E.	
Journal of the Royal Geographical Society, Nos. 2, 3, 4, & 5, Vol. XVI.; No. 1, Vol. XVII.	The Council of the Society.

Proceedings of the United Service Institution of India. Nos. 5, 6, 7, 8, & 9	The Council of the Institution.
Minutes of Proceedings of the Institution of Civil Engineers. Vols. XXXIII. & XXXIV.	The Council of the Institution.
Sanitary Engineering. A Lecture.........	The Commandant, School of Military Engineering, Chatham.
Railways and Railway Signalling. do.	
Canals, Reservoir Dams, &c. do.	
Building Materials. do.	
On the Manufacture, Use, and Testing of Gas for Illumination. A Lecture	
Some Application of Theory to the Practice of Construction. By Colonel H. Wray, R.E. ...	
Campbell's Range Indicator	The Author.
Hart's Army List. Oct. 71, Jan., April, and July 72	The R.A. Officers' Library, Woolwich.
Maps:—	The Secretary of State for India.
District Cachar; Reconnaissance of the Looshai Country—Eastern British Frontier, bordering on Burmah and Muneepoor	
Country round Rawul Pindee, shewing Camp of Exercise of 1872–3; in 3 sheets on calico ...	
Andeutungen für die Ausarbeitung eines Befestigungs-Projectes, mit einem Atlas, von 8 Plänen	Lieut.-Colonel W. E. M. Reilly, C.B.
The Three Arms	Colonel A. M. Murray, R.A.
Outpost Duties.......................................	
Officers' Field Manual	
Lettres du Cardinal Mazarin, pendant sont Ministère	The French Government.
Professional Papers of the Corps of Royal Engineers. Vol. XX.	The Editor.
On Explosive Agents applicable to Naval and Military Uses, as Substitutes for Gunpowder...	Professor F. A. Abel, F.R.S.
Explosive Agents applied to Industrial Purposes..	
Life-size Photograph of the late Sir J. Herschel.	Mrs. Cameron, through Captain E. H. Cameron.
Military Transport and Supply in India.........	The Author.
The British Army and its Reserves. By Lieut. E. H. H. Collen, R.A.	
Examination Papers, Royal Military Academy, June 1872, October 1872	The Governor, Royal Military Academy.
Catalogue of the Royal Military Academy Library	
Washington Astronomical and Meteorological Observations. 1869.........	The Smithsonian Institution.
Report on Immigration by the United States Bureau of Statistics. 1871..................	
Smithsonian Report. 1870.......................	
Pyrology, or Fire Analysis. By Captain W. A. Ross, R.A. (6 copies)........................	The Author.
MS. Military Survey of the Environs of Kingston, Jamaica, from Spanish Town to Stony Hill Barracks; and Plan of Port Royal, Jamaica..	Lieut.-General R. Burn, R.A.

England a Military Nation. By Captain C. C. Saxton, R.A.	The Author.
Elementary Lectures on Military Law. By Captain Tulloch	The Author.
The Administration of Justice under Military and Martial Law. By Charles M. Clode, Esq.	The Author.
The Franco-Prussian War, in 7 parts. Edited by Captain H. M. Hozier	Lieut. T. C. Cooke, R.H.A.
Observations upon Cæsar's Commentaries Military Observations on the Tacticks put into Practice, A.D. 1672	The Committee, R.A. Mess, Dublin.
Course on Artillery *Matériel* Italian Artillery Journal for 1870 & 71. Official, 2 numbers Do. Non-Official, 2 numbers	The Italian Government.
The Strength of Materials and Structures. A Text Book of Science	J. Anderson, Esq., C.E., &c., &c.
The Guns of the "Hercules." A Lecture by Commander W. Dawson, R.N.	The Author.
Geology of the Straits of Dover On the Agricultural Geology of the Weald. By W. Topley, F.G.S.	The Author.
Address for a Royal Commission on the Army Control Department. Speech of Major G. Arbuthnot, M.P.	The Author.
A Photograph of the Great Gun of Beejapoor—the "Moolk-i-Meidan," or "Master of the Field."	Doctor Day, 5th Bombay N.I., through Lieut. Mainwaring, R.A.
Bashforth's Motion of Projectiles	The Author.
The History of the Royal Artillery. Vol. I. By Captain F. Duncan, M.A., D.C.L., &c., &c.	The Author.
Observations of Solar Spots. By R. C. Carrington, F.R.S.	Major W. D. Carey, R.A.
Russian Artillery Journal. Nos. 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, & 11. 1872 Small-Arm Journal. Nos. 1 & 2. 1872 Recueil Militaire	The Russian Government.
Transactions of the Literary and Historical Society of Quebec	Major T. B. Strange, R.A.
A Map of Central Asia	Brig.-General J. M. Adye, C.B.
Maps of the Boundary between the Territories of Great Britain and of the United States, west of the Rocky Mountains	Mrs. R. W. Haig.
Report IV., on Experiments made at Copenhagen, and Plans XLIX. to LVII. of a work on the new *Matériel* of the Danish Artillery.	The Officers, Royal Danish Artillery.
International Exhibition of Paris, 1867. Reports of the International Jury, in 13 vols.	Lt.-Colonel C. H. Owen, R.A.
Journal of the United Service Institution of Plymouth. No. 1, Vol. I.	The Council of the Institution.
International Nautical Telegraph. By Captain C. De Reynold, French Navy	Sir D. E. Wood, K.C.B., R.A.
On the Pressure Required to give Rotation to Rifled Projectiles. By Captain A. Noble, F.R.S.	The Author.

Manual of Tactical Exercises on the Map, for Cadets of all arms ....
Game of War. Map of an Imaginary District.
Manual of Small-Arms, with an Atlas of 28 Plates ....
Handbook for Preparing Explosive Engines used in War ....
Artillery Atlas, Technical Division (128 plates). Netherlands Artillery of Former Times (4 plates) ....
Succinct Review of the Practice of the Artillery during 1863, 65, 66, 68, 69, & 70 ....
Principles of Field Fortification, for Cadets of all Arms, with 32 plates ....
Principles of Permanent Fortification, for Cadets of all Arms, with 23 plates ....
Directions for the Transport of Troops by Railway ....
Report of an Experiment with a Rifled Iron Cannon ....
Topographical Map of the Kingdom of the Netherlands ....

} The Netherlands Government.

Books purchased.

Organization of the Military Land Forces of the Country.
Sowerby's English Botany. Vols. II., III., VII., IX., X., & XI.
Webster's Complete English Dictionary.
Recherches sur les Agents Explosifs Modernes.
German-Franco Campaign, 1870–71. First part, first section. Translated by Captain F. C. H. Clarke, R.A.
Report of a Committee on the Advanced Class of Artillery Officers, 1872.
Report of the Adjutant-General upon the Organization of the Royal Artillery, with the evidence on which that Report is founded.
The Ibis. Nos. 7 & 8, Vol. II., and No. 9, Vol. III.
The Wellington Prize Essay. By Lieut. Maurice, R.A.
Sharp's Birds of Europe. Parts 10, 11, 12, 13, 14, 15, & 16.
Report on the Euphrates Valley Railway.
Die Operationen der Isten Armee under General Von Steinmetz.
Defence de Sebastopol. Par Todleben. Vol. II., Part I.
Defence de Sebastopol exposé la Guerre Souterraine, 1854–5. Par M. M. Frolow, Colonel du Génie.
Monograph of the Pheasant. Parts V. & VI.
Palæontographical Society's Publication. Vols. XXV. & XXVI.
Histoire de la Campagne de 1866. Official.
The Strength of Materials and Structures. By J. Anderson, Esq., C.E., &c.
Traite de Balistique Extérieure. Par N. Mayevski.
The Birds of Great Britain. Parts 21 & 22. By J. Gould, F.L.S. &c., &c.
The Birds of Asia. Part 24. By do.
The Army of the North German Confederation. Translated from the German by Colonel E. Newdegate.
L'Armée Allemande, son Organisation, son Armament, sa Manière de combatte. Par un Général Prussien.

Gmelin's Handbook of Chemistry. Vols. XV., XVI., XVII., & XVIII.
Cavalry Field Duty. By Major-General Von Mirus.
Operations of War. By Colonel Hamley. Third Edition.
Todhunter's Plane Trigonometry. Fourth Edition.
Deschanel's Natural Philosophy. Translated and Edited by Professor Everett.
The Russo-Indian Question. By Captain F. Trench.
The Defence of the North-West Frontier of India, with reference to the Advance of Russia in Central Asia. By Colonel Sir Henry Green, K.C.S.I.
Main's Practical and Spherical Astronomy.
Bashforth's Motion of Projectiles.
War, with the Tactics of the Three Arms abridged. By L. Besançon, Superior Officer of Artillery. Translated by Lieut.-Colonel Inglefield, R.A.
The Nautical Almanac for 1874 & 75.
Dziobek. Taschenbuch für den preussischen Ingenieur.

5. *Museum.*—A list of the donations to the Museum is issued herewith.

Several officers have received instruction in Taxidermy, some of whom did so just before going to India; whence it is hoped they will send some results of their skill.

During the past year a few interesting additions have been made to the natural history collection, consisting of heads and horns of antelopes, &c., from South Africa, by Lieut.-Colonel F. R. Glanville, R.A.; also from India, by Captain A. H. Murray, R.H.A.; specimens of birds from India by Major J. R. Dyce, R.A., and Captain L. W. Taylor, R.A.; a few from St. Helena, by Captain J. R. Oliver, R.A.; British reptiles and birds' eggs by Captain Feilden, 4th Regt.; and a fine collection of shells from Ceylon by Major O. H. A. Nicolls, R.A.

Presentations to Museum.

Water Pheasant from India	Lieut. P. M. F. Baddeley, R.A.
One Pair of Sambur Horns One Pair of Elk Horns	Major T. B. Strange, R.A.
20 Birds from India	Major J. R. Dyce, R.A.
Specimen of Shoveller Duck	Captain B. Tupper, R.A.
2 Ducks from North America	Captain A. French, R.A.
A Piece of Ivory, cut from the Tusk of an Elephant of the Mhow Heavy Field Battery.	Captain H. L. Ellaby, R.A.
A Large and Valuable Collection of Shells from Ceylon	Major O. H. A. Nicolls, R.A.
9 Heads and Horns, 4 Tails, and 3 Feet of South African Antelopes 1 Head of Hyæna, and 1 Head of Jackal	Colonel F. R. Glanville, R.A.
A very Valuable Collection of Fossils and Mineral Specimens	The Rev. Eardley-Wilmot.
35 Birds from India	Captain L. W. Taylor, R.A.
Sabretache of the late Bengal Horse Artillery ...	Lieut.-Colonel G. A. Renny, VC, R.A.

4 Birds from St. Helena	Captain J. R. Oliver, R.A.
4 Heads and Horns of Animals shot near Saugor, India..................	Captain A. H. Murray, R.A.
A Helmet Proposed for the Royal Artillery	Anonymously.
Specimen of Reindeer Moss off the Doorefeld Mountains, Norway	Colonel G. Le M. Tupper, R.H.A.
A Number of Birds' Eggs. Also a Small Collection of British Reptiles, made at Aldershot.	Lieut. H. M. J. Feilden, R.A.
Bird Specimen from China Seas	Major M. P. Eden, R.A.
Model of "Sub-Collector's Jamma Bandi"......	Captain W. Hughes-Hallett, on his leaving the Regiment.
A Bird Specimen from Bermuda	G. Hunter, Esq., Asst.-Com.
Specimen of Zeolite from the Færoe Islands ...	Captain H. W. Feilden, 4th Regt.
13 Specimens of Choice Ores from Cornish Mines	Captain A. B. Brown, F.R.A.S., F.G.S., R.A.
An Afghan Knife	Lieut. H. Lyall, R.A.
Officer's Helmet of the late Bombay Horse Artillery; and Officer's Helmet and Gunner's Helmet, late Madras Horse Artillery	Qr.-Master R. H. New, R.H.A.

Indian birds, presented by Major J. R. Dyce, R.A.

Circus æruginosus.
" cyaneus.
Urrua bengalensis.
Coracias indica.
" "
Merula albocinctus.
Oriolus kundoo.
" "
" "
Pomatorhinus erythrogenys.

Pomatorhinus erythrogenys.
Acridotheres tristis.
" "
" ginginianus.
Coracia himalayana.
Sturnopastor contra.
" "
Centrococcyx bengalensis.
Casarca rutila.
Branta rufina.

Indian birds, presented by Captain L. W. Taylor, R.A.

Halcyon smyrnensis.
" "
Ceryle rudis.
" "
" guttata.
Pelargopsis gurial.
Nyctiornis athertoni.
" "
Coracias indica.
Oriolus kundoo.
" "
" melanocephalus.
Lanius lathora.
" "
" erythronotus.
Garrulus lanceolatus.
Dendrocitta sinensis.
" rufa.

Dendrocitta rufa.
Tockus gingalensis.
Megalaima caniceps.
" "
Xantholæma hæmacephala.
Picus cathpharius.
Chrysocolaptes sultaneus.
Centrococcyx bengalensis.
Coccystes melanoleucus.
Chalcophaps indicus.
" "
Francolinus vulgaris.
" "
Rhynchæa bengalensis.
Seena aurantia.
Sterna javanica.
" "

Birds from St. Helena, presented by Captain J. R. Oliver, R.A.

Phasianus torquatus.	Puffinus major.
Ægialeus pecuarius.	Phaeton æthereus.

Bird from China, presented by Major M. P. Eden, R.A.

Sula fusca.

Bird from Bermuda, presented by Mr. W. Hunter.

Phaeton flavirostris.

Presented by Captain Basil Tupper, R.A.

Shoveller Duck (Spatula clypeata).

Heads and Horns of Antelopes, &c., from South Africa, presented by Lieut.-Colonel F. R. Glanville, R.A.

Black-backed Jackal (Canis mesomelas).	Brindled Gnoo (Connóchetes gorgon).
Spotted Hyæna (Crocúta maculata).	Gnoo ♂ ♀ (Connóchetes gnu).
Spring-Bok ♂ ♀ (Antidorcas euchore).	Bonte-Bok ♂ ♀ (Damalis pygarga).
Hartebeest ♂ (Alcéphalus caama).	Quagga (Asinus quagga).

Heads of Antelopes, &c., from Central India, presented by Captain A. H. Murray, R.H.A.

Indian antelope (Antilope bezoártica).	Axis deer (Axis maculáta).
Nylghau (Portax tragocamélus).	Sambur (Rusa aristotelis).

Presented by Captain Feilden, 4th Regt., through Lieut. H. M. J. Feilden, R.A.

Collection of British reptiles in spirits.	Temminck's stint (Tringa temminckii), two specimens.
Eggs.	Laughing gull (Larus atricilla), two specimens.
Purple sandpiper (Tringa maritima).	

Presented by Major O. H. A. Nicolls, R.A.

A fine collection of shells from Ceylon.

6. *Classes.*—The Drawing Class has been well attended. Several officers have received instruction in Photography.

7. *Observatory.*—The Observatory has been throughout painted and cleaned during the past year, and the Committee is happy to be able to announce that the equatorial telescope, which has been so long expected,

is now erected, and in excellent working order. Some delay was caused by the discovery that the floor of the equatorial room was rigidly connected with the brick structure upon which the stone pier supporting the telescope should rest, and also that a large stone across this structure was cracked. This necessitated the procuring and hoisting in of a fresh stone, and the separation of the floor from it. The stone was procured from the R.E. Department, and hoisted in by a detachment of gunners, under the able superintendence of Major Betty, R.A.

The report of the Sub-Committee, together with a technical description and engraving of the working parts of the telescope, will appear in an early number of the "Proceedings."

8. *Photography.*—A comparison of the sums spent on and received for Photography, shows that by the present system this department of the Institution has been self-supporting.

9. *Instruments.*—The instruments are in working order, but the Committee regrets that little use has been made of them during the past year.

10. *Model Room.*—This has been kept well up to date.

11. *Workshop.*—The shop has been used considerably during the past winter by members, and constantly by the carpenter of the R.A. Institution.

12. *Lectures.*—The following lectures have been delivered during the winter in the Theatre of the Institution, and were generally very well attended. The Committee has to express its thanks to Captain F. Duncan, R.A., M.A., D.L., D.C.L., &c., &c., J. A. Hallett, Esq., Brig.-Gen. Sir J. M. Adye, K.C.B., R.A., and C. L. Bloxam, Esq., F.C.S.

Captain F. Duncan, R.A., M.A., D.C.L., &c., &c.	"Waterloo: Another Chapter in the History of the Royal Artillery."
J. A. Hallett, Esq.	"To Parents and Guardians." A Play by Tom Taylor.
Brig.-General Sir J. M. Adye, K.C.B., R.A.	"Central Asia."
C. L. Bloxam, Esq., F.C.S.	"What should we do without Coal?"

13. *Afternoon Meetings.*—These meetings, confined to the discussion of subjects of professional interest, have been well attended, and the thanks of the Committee are due to Major H. Le G. Geary, R.A., for the paper read by him upon "An Endeavour to Determine a Tactical Basis for the Artillery of England;" and to R. B. Shaw, Esq., for a paper on "Eastern Turkistan."

The former of these papers has been published in the "Proceedings."

14. The following officers have ceased to be members of the Committee, owing to departure from the Garrison, and their places have been filled up by the Committee, subject to the approval of the general meeting :—

Lieut.-Colonel Maclachlan,	by	Lieut. Loraine, R.H.A.
" de Havilland	"	Major Hardy.
Major Tweedie,	"	" Chamier.
Captain Warren,	"	Captain Stoney.
Lieut. Loraine,	"	Lieut. O'Malley.

Major-General Eardley-Wilmot and Lieut.-Colonel Drayson have become members by augmentation.

In compliance with Rule V., the following officers retire from the Committee, and are not eligible for re-election.

Colonel Desborough.	Captain Cameron.
Lieut.-Colonel Young.	Lieut. Geary.
Captain Ford.	Surg.-Major Fasson.

The following officers were elected to serve on the Committee, viz :—

Colonel A. T. Cadell.	Captain R. S. M. Mackenzie.
" G. Leslie.	Lieut. F. Roberts.

Surg.-Major J. Gibbons.

The following resolutions were proposed :—

1. *Proposed by Lieut.-Colonel G. A. Renny, VC, R.H.A., seconded by Major H. Le Cocq, R.H.A., and carried unanimously* :—

"That the Report of the Committee be adopted and printed."

2. *Proposed by Lieut.-Colonel G. A. Milman, R.A., seconded by Lieut.-Colonel E. J. Bruce, R.A., and carried unanimously* :—

"That, in the opinion of the General Meeting, it is competent for any member, duly seconded, to move amendments to any subject under consideration."

3. *Due notice having been given, in accordance with Rule XX., the following addition to and alterations in the Rules were submitted by the Committee* :—

Addition to and alteration in Rule III. (*printed in italics*) :—

"III. The annual subscription of the several ranks, payable in advance on 1st April of each year, shall be as follows :—

	£	s.	d.
General Officers *ad libitum.*			
Colonels and Lieut.-Colonels	1	5	0
Majors	1	0	0
Captains	0	16	0
Lieutenants	0	10	0
Medical and Veterinary Officers and Paymasters according to relative rank."			

Amendment proposed by Lieut.-Colonel A. W. Drayson, R.A., and seconded by Captain A. Ford, R.A.:—

"That the words '*and Superior Officers*' be added after the word 'Lieut.-Colonels.'"

The amendment being put, was carried.

Rule III., as amended, was then put to the Meeting, and was also carried.

Alteration in Rule V. (printed in italics):—

"V. H.R.H. the Field Marshal Commanding-in-Chief to be Patron and President of the Institution. *The Inspector-General of Artillery, the Commandant of the Garrison, the Director of Artillery and Stores, the Deputy-Adjutant-General, and such other officers as may be specially elected at a general meeting, to be Vice-Presidents. The affairs of the Institution to be under the direction of a Committee, consisting of the above Officers, the Assistant-Adjutant-General, R.A., the Director of Artillery Studies, the Assistant-Adjutant-General, Woolwich, the Secretary, Department of Director of Artillery and Stores, and fifteen Officers elected at the annual general meeting, of whom four shall be Colonels or Lieut.-Colonels, and one Medical Officer, the senior to take the chair. The Medical Officer to retire every two years; one Colonel or Lieut.-Colonel,* and four members to retire annually, by rotation; and none of these to be eligible for re-election until the expiration of one year after leaving office."

Rule V., as proposed, was carried unanimously.

A vote of thanks having been proposed to the Chairman, was carried unanimously, and the meeting broke up.

THE MOBILITY OF FIELD ARTILLERY;

PAST AND PRESENT.

BY CAPTAIN HIME, R.A., F.S.S.

[No. V.]

"Les canonniers Anglaises se distinguent entre les autres soldats par le bon esprit qui les anime. En bataille, leur activité est judicieuse, leur coup-d'œil parfait, et leur bravoure stoïque."—*General Foy.*

Having described at length the different forces which determined the relative positions of the horse artillery and the field batteries at the beginning of the present century, it is now necessary to consider the influences which gave a considerable impetus to the field artillery service at large at that period. Without the operation of these influences, the horse artillery would not have been so good as they then were, while the field batteries would have been, if it were possible, worse. These influences were two in number—first, the wonderfully rapid progress of the arts and sciences at the end of the 18th century and the beginning of the 19th; and secondly, the appearance on the stage of war of the three greatest artillery officers the world has yet seen—Napoleon, Senarmont, and Drouot. In the case of England, a third influence must be added—the delivery of the army, by a long and bloody series of wars, from the obscurity in which it had long languished, in consequence of our insular position and the supremacy of our navy.

I.—The marvellous progress of physical science during the latter half of the 18th century, was chiefly owing to the natural reaction of the mind of man after centuries of protection and tyranny. For centuries the physical sciences had been consigned to the land of forgetfulness; for centuries it was dangerous to think, it was death to write upon them. "Innovation of every kind was regarded as a crime; superior knowledge excited only terror and suspicion. If it was shown in speculation, it was called heresy; if it was shown in the study of nature, it was called magic."[1] The cause of this tyranny is neither doubtful nor obscure; for it has been pointed out by the greatest thinker of his age—Lord Bacon.[2] "A theological system had lain like an incubus upon Christendom, and to its influence, more

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[1] Lecky's "Rise and Influence of Rationalism in Europe," Vol. I. p. 275.

[2] In his "Novum Organum."

than to any other single cause, the universal paralysis is to be ascribed. . . . . . It is, indeed, marvellous that science should ever have revived amid the fearful obstacles theologians cast in her way. Together with a system of biblical interpretation so stringent, and at the same time so capricious, that it infallibly came into collision with every discovery that was not in accordance with the unaided judgments of the senses, and therefore with the familiar expressions of the Jewish writers, everything was done to cultivate a habit of thought the direct opposite of the habits of science. The constant exaltation of blind faith, the countless miracles, the childish legends, all produced a condition of besotted ignorance, of grovelling and trembling credulity, that can scarcely be paralleled except among the most degraded barbarians."[1] The chains of this tyranny were not lightly to be cast off, and it was only by the struggles of ages that men at last succeeded in raising the prostrate sciences out of the dust. Isolated and widely separated discoveries had previously been made, in spite of the Church; but it was not until the latter half of the 18th century that the sciences raised their heads erect, unshackled by the chains of bigotry and fanaticism. When the reaction did come, it came with the rush and roar of the hurricane; and Mr. Buckle considers that in France, alone, more new truths concerning the external world were discovered during this period than had previously been discovered in the whole course of the world's history.[2]

The application of gunpowder to blasting had abridged the labour of the miner to a considerable extent; but no great advances in mining were made until the application of the steam engine to this art, towards the end of the 18th century.[3] The steam engine, too, aided by chemistry, which was advancing with long and rapid strides, assisted in hurrying on the progress of metallurgy; and chemistry and metallurgy rendered most important services to the artillery.

II.—By a capricious turn of fortune's wheel, the ruler of France at this time was at once a professional artillery officer and the greatest general of his age—[4]

"Impiger, iracundus, inexorabilis, acer;"[5]

and his guns were commanded by the two ablest artillery officers the service has ever seen. Nothing but glory could fall to the share of an artillery led by Napoleon, Senarmont, and Drouot. They keenly appreciated the great mobility of the horse artillery, but they were equally alive to the superior efficacy of fire of the field batteries; and by a just tactical combination of these two branches of the service, they succeeded in accomplishing feats of arms unrivalled in the history of field artillery.

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[1] Lecky's "Rationalism, &c." Vol. I. p. 274.

[2] "Hist. of Civilisation," Vol. III. p. 240. Leipsig Ed.

[3] Ure's "Dict. cf Arts, &c."

[4] General Foy speaks with bitter irony of the exclusion of English artillery officers from their just share of army commands:—"On a trop en horreur les avancemens hors de la règle, pour permettre qu'un Artilleur, ou un Ingénieur, qui se trouverait trop à l'étroit dans son arme s'élançât dans le service général de la ligne. Jamais de l'école de Woolwich ne sortira un Bonaparte."—"Hist. de la Guerre de la Péninsule," Tom. II. p. 297.

[5] Horace.

These grand results were achieved, for the most part, by using artillery as an arm, in masses, under its own superior officers; instead of the orthodox plan of frittering away its strength by scattering it in batteries and half-batteries among the different brigades and divisions of the army, under the command of infantry and cavalry officers. It is little surprising, however, that this system of artillery tactics, though adopted by the Germans in 1870-71 with brilliant success,[1] should be opposed, both in England and France, by a strong faction; for there is an unmistakeable tendency among a certain class of writers in both countries to heap discredit on everything relating to Napoleon, let alone his system of artillery tactics. His life was one vast sham, from the moment he first drew breath, until the dark hour when he—

> " . . . . trusting to his noblest foes,
> When earth was all too grey for chivalry,
> Died of their mercies mid the desert sea;"[2]

his rise was an accident; his victories were mere luck; and he fell at last only to the obscure level from which God and Nature had never meant him to rise. Be it so. The live ass may bray in safety over the dead lion. "They fools counted his life madness, and his end to be without honour; but he is in peace."[3]

III.—For an insular power like England, whose superficial area and population are considerably smaller than those of her continental neighbours, a large and powerful fleet is an absolute necessity. If she aims an offensive blow against an enemy, the transports in which her soldiers embark must sail under the protection of a strong fleet. If, on the other hand, an enemy meditates an invasion of her shores, the fleet becomes of greater importance than ever; for the first grand object naturally is, not to defeat him after he has landed, but to prevent him from ever effecting a landing. In fact, from whatever point of view the matter be regarded, the navy necessarily occupies the first and highest position among the warlike forces of an insular nation. If the policy of the nation be an offensive one, the fleet is of great importance; if its policy be defensive, the fleet is of infinitely greater importance. It is easy, then, to understand the influence which the navy exerts upon the army in England, or in any insular country. The more the money and attention lavished upon the navy, the less, in general, the attention and money spent upon the army. Except in time of actual war, the more efficient the fleet, the safer men will consider their lives, their freedom, and their property—especially when the policy of the country is one of peace, retrenchment, and non-intervention; and if peace lasts long enough, enthusiasts will

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[1] The truth of this statement has been frequently denied by English writers; nevertheless I deliberately and unhesitatingly repeat it. On the tactics of the German artillery in 1870-71, see Lieut. Maurice's "Wellington Prize Essay," pp. 64, 142; Verdy Duvernois, in the "Spectateur Militaire," Vol. XXIII. p. 238; Boguslawski's "Tactical Deductions," pp. 24, 60; a review of the "Infanterie, Artillerie, und Kavallerie im Gefecht, &c.," by the Russian Baron Seddeler, in the "Militair-Wochenblatt," 30th Nov. 1872, p. 913; Rüstow's "Krieg um die Rheingrenze, 1870," Vol VI. p. 98, *et seq.*; and Hoffbauer's "Die Deutsche Artillerie in den Schlachten bei Metz," Vol. II. p. 99, &c.

[2] Mrs. E. B. Browning.

[3] The Book of Wisdom, Chap. V. v. 4.

not be wanting to proclaim that the army is an unnecessary evil. That the existence of an army is an evil, cannot be denied; but the majority of sober-minded men appear to agree that it is a necessary evil, and that it would be imprudent to disband our army at present, even though Christianity is the professed religion of Europe.

A mere glance at the military history of England is sufficient to show that the mischievous pressure of the navy on the army is no fanciful idea, but a well-founded fact. From the invention of gunpowder to the conclusion of our continental wars in 1559, the English army was almost constantly engaged in the field abroad, and it was in consequence equal, if not superior, in all its branches, to any army in Europe. The navy had been also greatly improved and strengthened during these wars. On their close, the country was safe from invasion, and the army was neglected in all its branches until the time of William III. Indeed, the English artillery employed in the civil wars of Charles I. was probably the worst in Europe. During the reigns of William III. and Anne, active service again increased the efficiency of the army; but on the conclusion of Marlborough's campaigns our army returned home, to languish in the cold shade cast upon it by our splendid navy until the outbreak of the French Revolution. It is true that in the interim our army had been engaged in the Seven Years' War and the American War of Liberation; but the number of troops engaged was too small, and the time they were on service was too short, to counteract to any appreciable extent the influence of the navy. On the breaking out of the French Revolution, however, it was absolutely necessary to bring, not only the navy, but the army to the highest degree of efficiency, because it was necessary for the army to take the field in force; and it was thus completely freed from the prejudicial influence of the navy from 1792 until 1815. I need hardly explain that the influence of the navy affected the army in all its branches, and that the artillery suffered no less from it than the infantry and cavalry.[1]

It is not difficult to trace the influence of the rapid progress of the arts and sciences, and of the appearance of Napoleon and his artillery generals, on the mobility of field artillery; and it is only natural to find that these two general causes first produced tangible effects in France, for from political causes she afforded the best field for their operation. At war with monarchy, the Republic could not brook Dulness. She had almost stifled Gribeauval;[2] but she could no longer stifle enquiry, discussion, and invention; for the mother of invention was at hand, Necessity.[3] In France, then, naturally, the first feeble attempt to improve the field batteries was made; and as early as 1791, *wurst*, or car batteries were equipped and sent into the field.[4] The *wurst*

[1] The only writer who has dwelt on the influence of the navy upon the English army is, strange to say, a Frenchman—M. Brunet, in his "Hist. Générale de l'Artillerie," Paris, 1842. Tom. II. p. 118. The subject is just mentioned by an anonymous writer in an old number of Colburn's "United Service Magazine," the date of which I forget; but from his language, I suspect he borrowed the idea from M. Brunet, and forgot to acknowledge his obligation.

[2] "Les améliorations les plus incontestables furent combattues, avec un déplorable acharnement, par les nombreux partisans de l'ancienne routine," says M. Mazé, in his introduction to his translation of Jacobi's "Etat actuel de l'Artillerie de campagne Anglaise," p. viii.

[3] "Ce n'est peut-être qu' à l'urgence des circonstances," says Gen. Favé, quoting Scharnhorst, "qu'on doit attribuer l'accroissement qu'elle (the French artillery) reçut."—"Le Passé et l'Avenir de l'Artillerie," par S. M. Napoleon III., continued by Gen. Favé, Tom. V. p. 12.

[4] "Geschichte des Geschützwesens, &c.," C. von Decker, p. 151.

was a two-wheeled ammunition carriage, resembling in a general way an Irish jaunting car; the gunners sitting in two rows, facing outwards, with the ammunition between them.[1] The existence of these cars in France was a short one; for, in addition to the danger of bringing them under fire, they possessed not only all the evils belonging to two-wheeled military carriages, but the unpleasant quality of constantly upsetting on the slightest provocation.[2] Taken all in all, however, they were an improvement, and their introduction was "a clear admission that the guns had not yet attained efficiency of movement."[3] The adoption of cars in England was due to an unusually severe "invasion panic" which arose in 1803. In that year the Peace of Amiens was ruptured, and it was universally believed, and not without good reason, that Napoleon, in person, meditated an invasion of England. Confusion and terror reigned throughout the British Islands, and under these feelings the usual futile attempt was made to organise at a moment's warning what can only be organised after calm deliberation, free discussion, and extensive experiment—a field artillery that can move as well as fire. Cars were introduced; and so strong was the feeling in their favour, that they were supplied even to the horse artillery, although they were so heavy that "one box, of the three which the body of the wagon contained, was always ordered to remain empty."[4] After a few years' experience the cars were found wanting, and were discarded; but although they failed, they were nevertheless productive of two great benefits to the service—"their admission provoked discussion and trial, and the field artillery was for the first time fairly committed in England to the hands of the officers of artillery."[5] The immediate result of this movement was the construction of a lighter and better ammunition cart, on four wheels, and the adoption of the present wagon, or field battery system, in England and France.[6]

It is unnecessary to explain that the car system is, at bottom, identical with the wagon system—the only distinction being the difference of construction of the two carriages; and it is equally unnecessary to add that the only advantage the wagon possessed over the car, was its four wheels and larger supply of ammunition. The car was a carriage intended originally for the transport of the gunners, in which a certain supply of ammunition was stowed away; the wagon was a carriage intended originally for the transport of ammunition, on which the greater part of the detachment was mounted: but both involved the fatal necessity of bringing the ammunition carts under fire, when the guns advanced into action at a trot.

The second sign of the operation of the forces I have described, was the abolition of battalion guns. As the cars were first adopted, so the battalion guns were first discarded, in France; the system having fallen into disuse

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[1] Col. Timbrell, late Bengal Artillery, who has given me much valuable information about the cars, compares them roughly to short two-wheeled fire-engines.

[2] C. von Decker, as quoted above; Sir A. Frazer's "Remarks, &c.," p. 55. Col. Timbrell, who, as a Woolwich cadet, was an eye-witness to the performance of the cars on parade, fully endorses the statements of these two writers.

[3] Sir A. Frazer's "Remarks, &c." p. 54.

[4] Ibid.

[5] Ibid. p. 56.

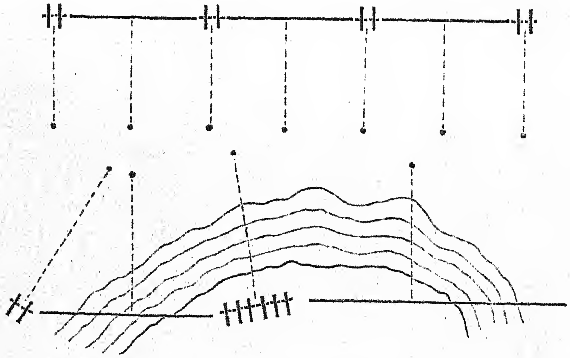
[6] Ibid. Favé's "Hist. et Tact. des Trois Armes," p. 268. The wagon system had been "partially practised in 1794" by the English artillery. See Frazer's "Remarks, &c." p. 58.

practically in 1793, and officially in 1796.[1] It was gradually done away with, all over Europe, during the early years of the present century.

The disuse of battalion guns is generally ascribed by military writers to the French Revolution and the creation of the divisional system;[2] but be it remembered that the divisional system was a direct consequence of the French Revolution and of the new conditions under which the raw soldiers of the Republic were obliged to fight, and that the Revolution itself was the direct result of the glorious *renaissance* of the arts and sciences, of learning and thought, of which I have spoken sufficiently.[3]

To the honor of the Royal Artillery be it said, that the first officer who raised his voice against this pernicious system of dissipating the force of the field artillery, belonged to the Regiment.[4] In an almost forgotten MS., in the library of the Royal Artillery Institution, may be found Major S. P. Adye's protest against the use of battalion guns, dated 1788. Major Adye saw clearly the important influence which the nature of the ground exerts on the fire of field artillery, and by two simple sketches he shows the difference between how guns ought to be placed, and how they then were. Fig. 1 shows the mode in which Major Adye proposed that a brigade (battery) of guns, attached to a brigade of infantry, should be posted—a disposition which was afterwards adopted substantially by all the great tacticians of the day.[5]

Fig. 1.



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[1] Lieut.-Col. Owen's "Modern Artillery," p. 303. The office is generally three years behind the parade-ground.

The temporary re-introduction of battalion guns by Napoleon into the French service, in 1805, is said to have been occasioned by the necessity of fortifying the courage of his young soldiers. See C. von Decker's "Geschichte des Geschützwesens, &c." p. 13, *note*. I have neither the desire nor the means of verifying this explanation.

[2] I mean the organisation of a division of the three arms as a tactical unit.

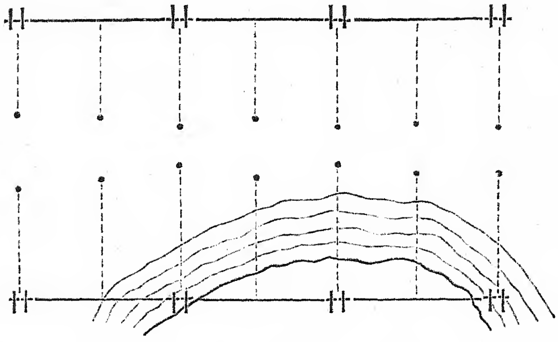
[3] See the 14th chapter of Buckle's "History of Civilisation."

[4] Many writers before Adye's time—for instance, Dupuget, in his "Essai sur l'usage de l'Artillerie," Amsterdam, 1771, p. 7—had objected to the system of battalion guns; but in general they only cast a passing glance at the subject, while Adye went to the bottom of it.

[5] I unfortunately only took a very rough copy of Major Adye's sketches when I saw them, eight years ago; but I think I have fairly reproduced their salient points.

Fig. 2 shows the ordinary disposition of infantry and battalion guns, according to the fashion of the day.

Fig. 2.



As Major Adye well points out, not only did "the infantry often suffer extraordinary inconvenience, such as being retarded on the march, &c.," from the battalion guns, but the tactics of the three arms were impossible while such a system prevailed. Strange that his words should have been almost repeated, eighty years after he wrote them, by Capt. May, the author of the celebrated "Taktische Rückblicke"![1]

The establishment of regular corps of drivers all over Europe, was cotemporary with the abolition of the battalion guns. Great is the obstinacy of man in general, but the obstinacy of soldiers is almost invincible; for the existence of an evil for ages past seems to be generally regarded by them as an argument that the evil should be perpetuated for ages to come. For a century, at least, the whole military world was well aware of the difficulty of dragging unwilling civilians under fire, and of the far greater difficulty of keeping them there. For a century, at least, the experience of every campaign showed that it was the wont of civilian drivers—were they English, French, Dutch, or Germans—to fly, with their horses, on the first available opportunity. As I have already mentioned,[2] in 1746 an English publication of repute spoke in strong terms of the loss of the guns at the battle of Falkirk by the flight of the drivers, and recommended that they should be "enlisted under the military oath."[3] Yet this state of things continued for another half century, and might have continued until now but for the sudden progress of mobility under the influence of the causes I have described!

The establishment of a corps of mounted and regularly enlisted drivers, was

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[1] "Wenn in einem Gefecht die Infanterie sich mit der feindlichen Infanterie herumschiesst, die beiden Kavallerien sich gegenseitig attakiren, die beiderseitigen Artillerien sich einander bekanoniren, oder wie der Kunstausdruck heisst, gegenseitig das Feuer auf sich zu ziehn suchen, so kann man nicht mehr von einer Taktik der verbundenen Waffen sprechen. Man begeht Fehler, die meistens nur desshalb ungestraft bleiben, weil sie der Feind auch begeht."—"Taktische Rückblicke," p. 32.

[2] See Mobility II., "Proceedings, R.A. Institution," Vol. VII. p. 144.

[3] "Annual Register," Vol. XVI. p. 28.

a vast improvement upon the old system of dismounted civilians; but the introduction of the drivers was by no means an unmixed good. Enlisted in a corps totally distinct from the regiment, and commanded by their own officers, the drivers were separated by a wide gulf from the gunners; and this want of connection between the field artillery and its means of draught led to discord, confusion, and waste of time. In 1817 the drivers were first placed under the command of the artillery officers, and in 1822 men were enlisted into the regiment as gunners or drivers.[1]

The progress of improvement was equally rapid in other branches of the service. In 1792 Sir W. Congreve invented the block-trail;[2] in 1804 an Englishman invented the limber-hook;[3] and ere many years elapsed the discoveries made in chemistry and metallurgy furnished the artillery with stronger gunpowder,[4] and with guns which, though much lighter than formerly, could be fired with reduced windage.[5]

The absolute effect of these improvements can only be measured by examining the position and behaviour of the artillery in the field; and a glance at the military history of the time is sufficient to show that, numerous as had been the improvements, many more were needed to make the artillery thoroughly efficient.

The increased rapidity of manœuvre which the enlisted and trained drivers conferred upon the field batteries, was shown on the very first occasion on which the Royal Artillery met the French in the Peninsula—the combat of Roriça. At the beginning of the fight, Col. Landman, R.E., brought orders to Geary's brigade (battery) to advance. Capt. Geary's brigade broke "from a walk to a trot, and from a trot to a full gallop. On nearing a small stone bridge over the rivulet of Columbeira, another brigade appeared on our right, dashing along through the deep sands, and evidently racing against Geary's, to obtain possession of the bridge; for on that must depend who should move on, there being no order for two brigades. Geary himself took possession of the bridge, a few yards only ahead of both the brigades, and thus gained the point; the other brigade of course immediately halting."[6] In 1798 an artillery general, reviewing some miserable batteries whose teams were driven by civilians on foot, announced gravely that field artillery movements could not be quicker performed; in 1808 we read of a brigade "dashing along through deep sands at full gallop!"—

"O miseras hominum menteis! O pectora cæca!"[7]

After the first eight days' campaigning in Portugal, during which the combat of Roriça was the only engagement, Sir Arthur Wellesley reported to his Government that he had been obliged to leave Spencer's guns behind altogether "for want of means of moving them," and that he must have left his own guns

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[1] "Kane's List."

[2] Owen's "Modern Artillery," p. 66, *note*.

[3] "Etude sur le Passé et l'Avenir de l'Artillerie." Par S. M. Napoleon III., continued by Gen. Favé, Tom. V. p. 16.

[4] Mr. H. Latham on "Early Breech-loaders," in the "Journal of the United Service Institution," Vol. IX. No. 34.

[5] Owen's "Modern Artillery," p. 8, *note*.

[6] Landman's "Recollections of my Military Life," Vol. II. p. 152.

[7] Lucretius.

behind but for the horses of the Irish Commissariat![1] Eight days afterwards, and five days before the battle of Vimiero, he again complained that the artillery horses were not what they ought to be. "They have great merit in their way," he says, "as cast horses of dragoons and Irish cart horses, bought at £12 each! but not fit for an army that, to be successful and carry things with a high hand, ought to be able to move."[2] Such were the horses with which we began our Seven Years' War against the French, and the carriages were suitable to such animals. The pursuit of the enemy was not pressed after our first battle and first signal victory, Vimiero, because "the gun-carriages were so shaken as to be scarcely fit for service," and the batteries were "so badly and scantily horsed that it was doubtful if they could keep up with the infantry in a long march."[3] To complete the picture, the drivers were in a "disorganised state and wretched condition," although their inefficiency and almost general misconduct had been "the constant subject of complaint since the formation of the corps," in 1794.[4]

From the beginning to the end of the war, the practical failure of the wagon system was as clear as noonday. It was found impracticable to mount the gunners on the wagons—first, on account of the danger of bringing the ammunition under fire; and secondly, because the weight of the wagons, already great, was so increased by that of the gunners as to overpower the wagon-team.[5] The result may be anticipated. "Few, if any, instances of mounting the men on the guns and carriages can be found to have occurred on service during the whole course of the war," says Sir Augustus Frazer, "and many were the cases in which the guns were either not brought to the points where they were wanted, or arrived just after the moment of opportunity had escaped."[6] On the day after Salamanca, the immobility of a field battery well nigh caused a calamity which might have brought the war to an abrupt and disastrous end—the capture of Lord Wellington. We may feel certain that the accident was not due to any want of judgment or knowledge in the officer commanding the battery, for he was one of the best artillerymen in the army—Capt. (afterwards Sir Robert) Gardiner. "I happened," says Sir Robert, "to be employed in advance with a 9-pr. brigade, covered by the light infantry of the 1st division. . . . . . We were far in advance of the main body of the army, and on approaching a steep ascent, I discerned the Duke of Wellington on the summit, waving on the guns. We put out with all haste, and reaching the height, the duke pointed to a large body of French cavalry at a distance of five hundred yards, and only separated from him by an easy ravine. The horses, from the steepness of the ascent, could not measure their power in draught to the slow pace of the gunners (on foot); the gunners could not hasten theirs to that of the horses. It was a critical

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1 Dispatch, Lavos, 8th Aug. 1808.

2 Dispatch, Caldas, 16th Aug. 1808.

3 Napier's "Peninsular War," Vol. I. pp. 140, 164.

4 Sir A. Frazer's "Remarks, &c." p. 72.

5 On the 12th Aug. 1860, at Sinho, in China, the wagons of the three 6-pr. guns stuck fast in the heavy mud; and when the guns got into position, there were not more than a handful of the gunners with them, the rest being scattered all over the plain in rear. Subsequently, the wagons had to be temporarily abandoned, and the gunners accompanied the guns—which were attached to Pattle's cavalry brigade—mounted on the wagon horses.

6 Sir A. Frazer's "Remarks, &c." pp. 44, 57.

moment, threatening the duke's safety; for at the moment the guns reached the summit, the gunners were still labouring, breathless, only half-way up the ascent. The enemy, from some inexplicable reason, failed to charge or move till the guns opened fire."[1] History repeats itself. The very self-same incident happened, forty-two years afterwards, on the knoll above the river Alma!

It was fortunate for the duke that the Peninsula is, in general, a country ill-adapted for artillery, for his artillery was constantly inferior to that of the enemy. In 1812, he complained that his army had never had with it "an equipment of ordnance at all consistent with its numbers;"[2] and in 1813, he wrote to Government that owing to the deficiency in the number of horses, he would be obliged, "as usual," not only to take the field with an equipment of artillery far inferior to that of the French, but without a single spare horse![3] Finally, the driver corps, on which the success of the field artillery so essentially depended, "was a perfect military anomaly, so constituted as to render its own discipline or efficiency unattainable."[4] These were serious obstacles to success: but no danger could disturb, no difficulty could delay, no discouragement could arrest the victorious progress of the Royal Artillery; and its conduct in the field drew from General Foy the noblest meed of praise that has ever been bestowed on any branch of the British army by a foreigner and an enemy:—"Les canonniers Anglaises se distinguent entre les autres soldats par le bon esprit qui les anime. En bataille, leur activité est judicieux, leur coup-d'œil parfait, et leur bravoure stoïque." These words, be it remembered, were written in no times of friendly alliances and commercial treaties, but at a moment when, with Napoleon chained, like Prometheus, to a rock in mid-ocean, and with the disaster of Waterloo still fresh in their memories, the French were our bitterest enemies in Europe.[5]

I have already explained that, previous to the French Revolution, not only was the English artillery influenced by the same general causes that depressed the service throughout Europe, but, in addition, by the evil pressure of the navy. If, under such circumstances, the English artillery kept pace with the continental artilleries, it might be inferred that on the removal of the influence of the navy at the breaking out of the French Revolution, the English artillery would shortly outstrip its neighbours. And such was in reality the case, if we may trust—and there is no reason to distrust—French officers. The English artillery, says Gen. Favé, which was inferior to most others in the first campaigns of the Revolution, made such extraordinary advances during the progress of the war, that before the conclusion of the Peninsular War, the English *matériel* might have been taken as a model by any nation in Europe.[6] General Foy, who saw the English artillery after the Convention of Cintra, 1808, declares that no artillery could compare with the English in the light-

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[1] "Notes on the Organisation, &c., of the Artillery," 1856. p. 16.

[2] Dispatch, Villa Toro, 18th Oct. 1812.

[3] Dispatch, Frenada, 14th April, 1813.

[4] "Report on the Numerical Deficiency, &c., of the Royal Artillery," by Sir Robert Gardiner, K.C.B., R.H.A., 1848, p. 15. Wellington's Judge-Advocate-General pronounced the drivers to be "the greatest blackguards in the army."—Larpent's "Journal, &c."

[5] Foy's "Hist. de la Guerre de la Péninsule," though not published till 1827, was written in 1817.

[6] "Le Passé et l'Avenir de l'Art." Tom. V. p. 64.

ness of the carriages, and in everything connected with the means of draught;[1] and Marshal Marmont, after inspecting Webber Smith's troop, shortly before Waterloo, said "the equipment in every respect was very far superior to anything he had ever seen."[2] In 1815, after the occupation of Paris by the Allies, Capt. Parrizot, of the French artillery, in a memoir on the English artillery, said it was superior to all others in the following respects:—1st, interchangeability of *matériel*; 2nd, ease of limbering-up and unlimbering; 3rd, construction of the wheels; 4th, the transport of the gunners; and 5th, the system of draught.[3] Finally, the French Government appointed a committee of artillery officers to report on the various allied artilleries that took part in the grand review of the 23rd Oct. 1818.[4] After noticing the peculiarities of the different artilleries—the English guns with 8 horses; the Russian wagons with 3 horses abreast; the Danish heavy field-pieces with 12 gunners to each gun; and the Saxon batteries with a gunner on the off-leaders of the gun and wagon, 2 gunners on the trail seat, and 2 on the wagon limber—the committee unhesitatingly gave the palm to the English batteries. They were particularly delighted with the manœuvres of one field battery over very difficult ground, and they generously confessed that no French battery could have cleared the ground like the English. "By mounting the gunners on the gun-limber and wagon," said the committee, "by ridding the gunners of their cumbrous and useless carbines, and by attaching the knapsacks to the carriages, ... the English have made the field batteries a new arm."[5] During the whole time our army occupied France, the artillery excited the liveliest interest and admiration of the French officers, and they did not hesitate to say that our field batteries were the most mobile in Europe, whatever the ground and whatever the pace.[6]

Such was the splendid position of the English artillery in 1815—a position it was not long to hold.

The exhaustion consequent upon 23 years of war, imposed upon Europe a policy of peace and retrenchment, and a diminution in the budget naturally involved a diminution in the number, though not necessarily in the efficiency, of the artillery. Almost universally, however, the decrease in numbers was accompanied by a decrease of efficiency. Armies had long occupied the most prominent position in public estimation, and now, by a natural reaction, they were thrown into the shade and unduly neglected.

In England matters were worse than elsewhere. On the close of the war, we rushed to the demolition of our military establishments as if Satan had been bound for 1000 years, and there was to be no more war. An era of eternal peace had dawned upon the world, and happy England would float dreamily down a river of commercial and political prosperity that was to flow on for ever and for ever. She would no longer waste her wealth upon a brutal and licentious soldiery; she would set an example to the nations of the

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1 "Hist. de la Guerre de la Péninsule," Tom. II. p. 296.

2 Sir A. Frazer's "Letters, &c." p. 502. Marmont was an artillery officer.

3 Favé's "Le Passé et l'Avenir de l'Art." Tom. V. p. 72.

4 Ibid. p. 76.

5 "Ces dispositions font de l'artillerie à pied une arme nouvelle."—Ibid. p. 78.

6 "Nos officiers signalèrent particulièrement ses pièces, &c. &c., comme possédant des qualités remarquables et comme étant supérieures à toutes les autres par leur mobilité dans tous les terrains et à toutes les allures."—Ibid. p. 84.

security of unarmed virtue; and, rapt in admiration, mankind would enthusiastically exclaim—

> "Her armour is her honest faith,
> And simple truth her shield."[1]

It had been said—and said, too, by her greatest political economist—that certain dangers necessarily accompany the production and accumulation of wealth. "The shepherd," he explained, "has a great deal of leisure; a husbandman, in the rude state of husbandry, has some; an artificer or manufacturer has none at all. The first may, without any loss, employ a great deal of his time in martial exercises; the second may employ some part of it; but the last cannot employ a single hour in them without some loss, and his attention to his own interest naturally leads him to neglect them altogether. These improvements in husbandry, too, which the progress of arts and manufactures necessarily introduces, leave the husbandman as little leisure as the artificer. Military exercises come to be as much neglected by the inhabitants of the country as by those of the town, and the great body of the people becomes altogether unwarlike. That wealth, at the same time, which always follows the improvements of agriculture and manufactures, and which in reality is no more than the accumulated produce of those improvements, provokes the invasion of all their neighbours. An industrious, and upon that account a wealthy nation, is of all nations the most likely to be attacked; and unless the state takes some new measures for the public defence, the natural habits of the people render them altogether incapable of defending themselves."[2] So wrote Adam Smith. But who was Adam Smith? A thinker who lived in an age of war, revolution, and scepticism! War, revolution, and scepticism were things of the past; peace, plenty, and prosperity were things of the present. The army must be reduced. The army *was* reduced.

In vain the military authorities protested—the country was deaf as the deaf adder; and reduction followed reduction, although "upon every occasion on which an attempt was made . . . . . to reduce the force, a necessity was found to exist immediately for augmenting it again at a large expense, following a large expense incurred in the reduction."[3] This system of alternate reduction and augmentation, aggravated by the influence of the navy, which now set in with fourfold violence, necessarily acted with ruinous effect on the field artillery, and its fall was as rapid as its rise.

The symptoms of decay became first unmistakeably evident in the expedition to Portugal, only 11 years after Waterloo. The 4-gun batteries which accompanied the expedition were ludicrously under-horsed, and Col. Webber Smith, who commanded the artillery, was recalled because he took the spare ammunition horses to increase the gun teams from 4 to 6 horses. His successor, Sir John May, arrived in Portugal with 50 additional drivers—[4]

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[1] Quoted from Sir Wilfred Lawson's speech on the Army Estimates in the House of Commons, 28th Feb. 1873.

[2] Adam Smith's "Wealth of Nations," Vol. II. p. 280. Rogers' Ed.

[3] The Duke of Wellington to Lord Goderich; Supplementary Dispatches of the Duke of Wellington, Vol. IV.

[4] Sir John was shipwrecked, and had in person to march the drivers from the point of the coast on which they had been cast to the head-quarters of the artillery—120 miles.

a practical acknowledgement on the part of the authorities that the artillery was under-manned—and his first act was to report that he considered the measures taken by Col. Smith necessary and right. After 11 years of peace, at a time when annual practice was unknown, a short course of practice for the gunners would not have been superfluous; but not only was there not a single round of service ammunition allowed for this purpose, but the supply of blank cartridges was insufficient for the field days. The cartridges had to be subdivided, and to such an extent, that at one of the field days the force of the powder was not sufficient to expel the tubes from the vent; the tubes stuck fast, to the merriment of the other troops and the spectators; and the artillery was sent back to barracks that the tubes might be extracted. The gunners were as deficient in numbers as the drivers and horses; the detachments could only muster five or six men each; and "there were no men in reserve, to replace the sick or the store guard."[1] The English wheels, which had excited such admiration in 1815, were now a laughing-stock to the Portuguese. The tires were fastened on the felloes by long nails, instead of bolts with nuts, and pieces of the tire were constantly flying off, especially when the batteries moved at a trot. The gun detachments had to be held responsible that these pieces were not lost! The cavalry farriers had a contract for their shoes and nails; but shoes for the artillery horses were issued out of store, and were of such a "monstrous size"[2] that they all had to be reduced to fit the horses. This reduction had to be carried out in a field-forge with a charcoal fire, and involved an extraordinary amount of unnecessary labour. The nails were so bad that "there was no end of re-shoeing going on; and on the return of the batteries from ordinary exercise, or even watering order, a dozen horses or more required the shoeing-smith's attention in each battery."[3] The result was that a number of the horses got sore or tender feet, from constant shoeing and re-shoeing. Nor was this all; for, from time to time, large fatigue parties of the already overworked gunners had to scour the drill ground in search of broken nails and shoes. Fortunately the expedition did not fight, and returned to England after peacefully occupying Portugal for some months.

As years rolled on, matters went from bad to worse. Like Tithonus, the field artillery grew, day by day, more attenuated and more enfeebled; until at last, in 1848—a year damned to eternal fame in the annals of the regiment—it had almost ceased to exist, except in name. In that year was heard a voice in the military wilderness—a voice proclaiming with no uncertain sound that England was "actually without a field artillery."[4] "It is a delusion," said Sir Robert Gardiner, "it is a delusion to say England has a field artillery. There is not a single 9-pr. horsed in the British service."[5] "If any sudden emergency rendered it necessary to send field artillery from Woolwich to any threatened point on the coast, *fourteen guns* would be the utmost (really

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[1] The above details are due to Mr. Lazenby, Governor of the Brecon County Gaol, who served in the expedition to Portugal in the Ordnance Department, as Asst. Conductor of Stores.

[2] Mr. Lazenby's MS., in my possession.

[3] Mr. Lazenby's MS. Mr. Lazenby assures me that the Letter Book of the Head-Quarter Office, R.A. would amply prove that Sir John May's exertions to alter this state of things were unremitting; but that the parsimony of the home Government rendered all his efforts unavailing.

[4] "Illustrations of the Numerical Deficiency, &c., of the Royal Artillery," by Sir Robert Gardiner. 1849, p. 10.

[5] "Report on the Numerical Deficiency, &c., of the Royal Artillery." 1848, p. 8.

efficient and completely equipped) that could be forwarded. . . . . The drivers are unskilful, and ignorant of artillery movements, ... and I don't believe there is a reserve of 20 horses to meet all the wants and casualties of the whole British field artillery."[1] "The brigades at Woolwich are ill-organised, uninstructed, unskilled, and incapable of either riding or driving. . . . . Not one of the four are either fit or capable of moving; and on the 10th April last (1848), a field battery being ordered to London,[2] the gunners and drivers were so perfectly inadequate to the service, that they were removed, and other gunners and drivers substituted for the day."[3] It was chiefly owing to these vigorous remonstrances that England possessed the field artillery that landed in the Crimea. Peerages have been given before now for less important services.

Of the changes that took place in the field artillery since 1848, and of the causes that produced them, I shall not venture to speak; because I live too near the time to be capable of speaking of them with impartiality. Standing at the feet of the gigantic statue, I cannot measure its proportions with justness, and I leave the task to some future writer.

In my next, and concluding paper, I shall consider the influence of the recent changes in tactics on the mobility of field artillery.

GLASGOW,

March, 1873.

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[1] "Report on the Numerical Deficiency, &c., of the Royal Artillery." 1848, pp. 7, 16, 17.

[2] To overawe the Chartists.

[3] "Illustrations of the Numerical Deficiency, &c., of the Royal Artillery." 1849, pp. 14, 50.

ON THE PRINCIPLES

WHICH REGULATE THE

EFFICIENCY OF ARTILLERY PROJECTILES,

BY

LIEUT. E. CLAYTON, R.A.

THE R.A. INSTITUTION PRIZE ESSAY OF 1873.

"Amphora cœpit
Institui, currente rotâ cur urceus exit."

A clear understanding of the principles upon which the efficiency of artillery projectiles depends is of the utmost value, both for the most effective use of the *matériel* we at present possess, and for the direction of our attention to the paths in which the improvement of that *matériel* is to be sought.

These principles divide themselves broadly into two great classes.

Firstly, those affecting the chance of the projectile striking the object aimed at; and

Secondly, those which relate to the effect produced by the projectile when it does strike.

These two classes of principles will be found to touch one another at certain points; but it will be convenient to consider them separately, pointing out, as they present themselves, the circumstances under which they are mutually dependent upon one another.

We will proceed to consider first the principles of the first class.

When a projectile is fired from a gun, it describes a path through the air which is called its "trajectory;" the shape of this path being determined by the three forces acting on the projectile—the force of projection, the force of gravity, and the resistance of the atmosphere.

It will be out of place in this essay to go into the theory of the flight of projectiles; we will only consider the practical questions that arise.

The two conditions for rendering the chance of hitting the object aimed at as great as possible, are accuracy of flight and lowness of trajectory.

Accuracy of flight is sought to be obtained by giving the projectile a rotation round an axis coincident with that of the bore of the gun, so as to counteract the effect of the resistance of the air, and of inequalities in the density of the shot in different parts, tending to produce eccentricity of the centre of gravity, and of irregularity of motion in the bore of the piece. This rotation also allows of the use of elongated projec-

tiles; and the resistance of the air to these being less than to spherical projectiles of the same weight, an increased range is obtained.

Many systems have been advocated for imparting this rotatory motion —some affecting both the gun and projectile, and some the latter only. None of the systems affecting the projectile alone have been practically adopted, and all nations use guns and small-arms rifled upon various systems.

All systems of rifling have certain principles in common, and certain conditions which must be fulfilled.

The conditions to be fulfilled are—that the velocity of rotation of the projectile must be sufficient to keep it steady to the end of its flight; that the projectile should be centred at the moment of its leaving the bore of the gun, so that the rotatory motion may be given accurately round the axis of figure of the projectile—or an eccentricity of rotation would ensue, which would cause the resistance of the air to act more on one side than the other, and cause irregularity of flight; and that the axis of the projectile should be stable on leaving the gun.

In estimating the amount of twist to be given to the rifling in a gun, the following principles must be borne in mind.

Solid shot require a greater velocity of rotation, and therefore a sharper twist, than shell of the same weight; because in the latter the distribution of the mass is nearer the circumference of the projectile, and therefore the radius of gyration is increased.

With the same calibre, the sharpness of twist of the rifling must increase with the length of the projectile; as in a long shot the resistance of the air has a greater tendency to turn the shot over on its shorter axis, on account of the greater leverage with which it acts.

The less the density of the material of the projectile, the greater must be the twist; as a light projectile loses its velocity of rotation quicker than a heavy one.

The centre of gravity of a projectile should be as near its centre of figure as possible, to ensure the greatest steadiness of flight.

The greater the initial velocity, the greater the velocity of rotation that will be required, as the resistance of the air will be greater; but with a certain amount of twist, these two velocities bear a constant ratio to one another, and as one increases, in the same proportion does the other also increase, and no sharper twist in the rifling will be required for an additional initial velocity.

The shape of the head of the projectile will also influence the amount of twist that must be given; for in the case of a flat-headed projectile, the resistance of the air acts almost at right angles to the flat head, and must therefore exert a much greater effect than in the case of a hemi-spherical or pointed head, when the air has merely to part and flow round it.

When we, therefore, wish to decide upon the amount of twist we propose to give to the rifling of a gun, we must consider the most unfavourable projectile we wish to throw from the gun, and give a sufficient twist to keep it steady in its flight to the extreme range, and then we may be sure that it will be sufficient for every case. It would

be very difficult to calculate this theoretically; it must therefore be decided experimentally.

An important point in gunnery is the relation between the weight of a projectile and its calibre. In days of smooth-bore ordnance, when all projectiles were spherical, this question did not arise; but now it is both necessary and difficult to decide what is the proper proportion between the weight and calibre of a projectile. In connexion with this subject comes up that of lowness of trajectory.

Lowness of trajectory is advantageous—

(1) On account of greater accuracy.

(2) On account of harder hitting—for lowness of trajectory means greater velocity, and consequently more energy in the shot.

(3) On account of the greater distance covered effectively by the projectile—"longueur battue," as the French term it; that is to say, a projectile with low trajectory passes over a greater distance within the height from the ground reached by the objects fired at, than one with a high trajectory.

It has been mentioned above that a lower trajectory implies a greater velocity—for projectiles drop equal distances in equal spaces of time, and the quicker they are moving the greater space they pass over while falling any given distance; but it must be clearly borne in mind that the velocity which gives effective lowness of trajectory is not *initial* velocity, but the velocity remaining when the projectile arrives within the *rayon* of the objects aimed at; and it is not at all necessary that the projectile that has the greatest initial velocity should have the greatest remaining velocity at a given range, for it may easily be that a projectile of such a shape as to experience much resistance from the air may start with an initial velocity considerably higher than that of a second projectile of a form to experience little resistance, and that the first should lose its velocity so rapidly as to be caught up and passed by the second before it reaches the end of its range. Our object, therefore, will be to obtain as great a remaining velocity as possible.

If two projectiles are of equal weight, and have similarly shaped heads, the one which is longer with smaller calibre will experience less resistance from the air, and will therefore lose its velocity slower than the other. The inference comes at once that guns should be made of small calibre, and that long projectiles should be used.

But there are certain things to be considered which point in the opposite direction.

It is true that if two projectiles start with the same initial velocity, the one of smaller calibre will have a greater velocity at the end of a certain range; but in a gun of a very small calibre the cartridge becomes very long, and the powder is blown out partially unconsumed, unless the gun is of inordinate length, so that the projectile will not start with the initial velocity that one would from a gun of larger calibre that burnt all its powder. Moreover, the longer projectile requires a sharper twist to keep it steady, and this causes a greater strain upon the gun. Again, the internal capacity of a long shell of small diameter is less than that of one of the same weight and larger diameter; so that

too great a diminution of the calibre would injuriously diminish the efficiency of the shell. This is one of the points at which the principles of the two classes are interdependent.

In determining the calibre to be given to a gun to throw a projectile of a certain weight, we must, therefore, balance these advantages and disadvantages, and determine the diameter of bore we choose by an argument of the following nature.

The diameter of the bore should be reduced as much as is consistent with the capacity of the gun to burn sufficient powder to give the projectile such a remaining velocity as may be considered necessary at its extreme range, and consistent with not impairing the efficiency of the shell or shrapnel.

Very considerable initial velocity may be given even to a projectile of small calibre in a breech-loading system, by a slight chambering of the gun at the seat of the cartridge, so as to diminish the length of the cartridge and cause the powder to burn quicker, in which case a considerable flattening of the trajectory would ensue. It has been stated lately that the French have constructed a field gun which has thrown its shot with the extraordinary initial velocity of 2000 ft. per second. If this is true, the result has probably been obtained by the chambering which they have employed. It is a subject worthy of consideration whether any device can be discovered to enable a chamber to be used with muzzle-loading ordnance.

Another consideration to be borne in mind is, that as with a smaller calibre a lower initial velocity is required to give an equal remaining velocity, the shock of recoil will be less, and therefore the weight of gun and carriage may be reduced—which is a subject of importance in connection with the mobility of field artillery.

The increased strain caused by an increase of twist, will not be great enough within the practical limits of the decrease of bore for it to be necessary to take it into consideration.

All that has been said hitherto is applicable to all systems of rifling. We will now endeavour to discover what are the principles that should guide us in choosing a system for adoption.

All the systems at present proposed may be divided into four classes.

(1) Breech or muzzle-loading systems, with hard mechanically-fitting projectiles.

(2) Breech-loading systems, with projectiles slightly larger than the bore, and covered with a soft metal coating, which is forced into the grooves as the projectile is driven through the bore by the force of the explosion of the powder.

(3) Breech or muzzle-loading systems, with hard projectiles having a soft expanding base or coating.

(4) Breech or muzzle-loading systems, having hard projectiles with soft projecting studs.

It is found that all these classes of systems give practically equal results as regards accuracy of fire, if fired under suitable conditions of charge, angle of twist of rifling, &c.; so we must look to other points to enable us to make our choice between them.

In the first place, we notice that systems of the second class are necessarily breech-loading. We have not space to go into the question of the rival merits of muzzle-loading and breech-loading; but we observe that if it be decided that muzzle-loading is best, the systems of this class must be necessarily rejected.

The other conditions we must look to in making our decision are as follows:—

Ease, cheapness, and certainty of manufacture.

Liability to injury or deterioration.—Mechanically-fitting iron and steel projectiles are liable to rust; and this is a serious matter, as on account of their small windage a very slight departure from smoothness will cause the shot to jam in the bore, either in loading or discharge. Soft-coated and studded projectiles get their coatings and studs injured by the shocks of transport. Studded projectiles appear to be rather weakened by the holes cut in them for affixing the studs.

Liability of shot to jam in the bore.—Hard mechanically-fitting projectiles are liable to this fault, either from carelessness of manufacture or rust, on account of their small windage. Studded projectiles have also been found to jam, through the studs being forced out of the grooves and caused to override the lands.

Safety in use.—The first lead-coated projectiles were dangerous to fire over the heads of your own troops, as the lead used to strip off. This fault has, however, been rectified.

Liability to injury of the bore of the gun.

Fuzes.—Systems which have no windage, or very little, cannot ignite their fuzes by the flame of the explosion. Complicated percussion arrangements are therefore required to ignite the time fuzes, which render them very uncertain in their action, and expensive. The Germans, however, say that their time fuzes act sufficiently well if used fresh, before they have had time to deteriorate.

So far we have been considering the principles of the first class—viz., those which affect the chance of hitting; let us now turn to those of the second—viz., those which influence the effect produced.

The former class we were able to discuss generally, as the same principles hold good whatever may be the object fired at; but in discussing the second class, we must consider the various objects aimed at, and services required, separately.

We will consider the services in the following order:—

(1) Artillery for ships and coast defences.
(2) " fortresses and siege works.
(3) " field service.

And in each case we will consider the principles by which, and the conditions under which, the projectiles will produce the most effect.

I.—*Naval Service and Coast Defences.*

Ship guns may have to be used either against armoured or unarmoured ships and boats, against coast batteries and fortifications of iron, masonry, or earth, or for bombardments.

There are two methods in which armoured ships may be attacked—either by "punching" holes through their plates and sides, or by what is termed "racking"—that is, ruining the structure by the shaking effect produced by the impact of heavy projectiles that do not pierce the armour. It was seen in the last American war what an immense amount of battering an armoured vessel could stand without being disabled, as long as her plates were not pierced; and we in this country have decided that the method of attack by punching is the most effective.

The principles which affect the punching power of projectiles have been worked out, partly by mathematical investigation and partly by experiment. Before stating them, it will be necessary to define the term "energy."

"Energy" is the amount of work in a shot when it strikes an object, and is calculated thus:—

$$\frac{wv^2}{2g} = \text{energy in foot-pounds};$$

where

$$w = \text{weight of shot in lbs.},$$
$$v = \text{remaining velocity in ft. per second},$$
$$g = \text{accelerating force of gravity}.$$

It is found that the power of piercing unbacked armour plates decreases as the diameter of the projectile increases; and therefore energy is generally expressed in foot-tons per inch of circumference of the projectile, or

$$\frac{wv^2}{4\pi rg \times 2240} = \text{energy in foot-tons per inch of circumference}.$$

The following principles were found to hold good in practice against armour plates:—

Solid steel shot, with similar forms of head and of equal diameter, penetrate unbacked iron plates with equal facility if they strike with equal energy, however that energy may be compounded of weight and velocity within practical limits—that is to say, the same effect is produced by a light shot with high velocity, as with a heavy shot with low velocity.

Solid steel shot of different diameters penetrate with equal facility if they strike with energy proportionate to their diameters.

The resistance of unbacked iron plates of different thicknesses varies as the square of their thicknesses.

From the first two of these principles it may be easily seen that the law may be generally stated that solid steel shot of similar forms of head penetrate unbacked iron plates with equal facility, if they strike with equal energy per inch of circumference.

In firing obliquely at iron plates, it was found that in all cases, as long as the projectile did not glance off the plate, the penetrating effect was directly proportional to the sine of the angle between the line of fire and the face of the plate.

On experimenting with shot of different materials, it was found that

if cast-iron shot were used, a very high velocity was needed to pierce the plate, but with hard materials, such as steel or chilled iron, a high velocity was not so necessary, the effect being equal when shots struck with equal energy, which might be compounded in any proportion between weight and velocity within practical limits.

With regard to the best shape of head to be given to the projectile, it was found that against unbacked plates the shape of head, whether flat, hemispherical, or pointed, made very little difference; but against backed plates the pointed ogival head had a great advantage. When hemispherical or flat-headed projectiles pierced a backed plate, they punched out a piece of the iron and carried it before them into the backing, and could not rid themselves of it; but the ogival-headed shot tore a way for itself through the plate, bending back its edges into the backing, but carrying no portion of the iron before it. It was found, however, that the ogival head did not answer so well with steel as with chilled iron.

It was also found that with blunt heads (hemispherical and flat) much energy was wasted in setting up the head—that is, in flattening it out and bulging the shot; whereas the pointed projectiles passed through almost unchanged in shape. Blunt-headed projectiles also suffer more resistance from the air.

In firing against inclined plates, it was found that the pointed projectiles dug their noses into the plates and turned round till their axes were almost at right angles to the plate, and were therefore in the most favourable position for penetration; whereas the blunt-headed shot ploughed up the metal of the plates till they were brought to rest by the accumulation in front of them, their axes being still parallel to their original position. It was found that ogival-headed shot would generally not glance if the angle between the line of fire and the plate was not less than the angle made with the axis of the shot by a tangent to the curve of the head at the point of the shot.

Shell were fired at the plates with bursting charges and without fuzes, and it was found that steel and chilled Palliser shells would penetrate the plates, and explode after passing through.

When Palliser projectiles were fired at iron plates, it was found that the heads passed through entire, but the bodies always broke up. If the projectile pierced the side of a ship, this breaking up would be very destructive, the pieces acting as langridge; but it is probable that a certain amount of energy is so lost.

Palliser projectiles with ogival heads are more effective than steel ones, if they are of good quality, and cost little more than one-fifth as much. It was found very difficult to get solid Palliser shot homogeneous throughout; they are therefore now cast with a hollow core, the heads being cast in chill and the bodies in sand. The hollow does not extend into the head in the case of shot, but it does in shell, the walls of which are rather thinner. Good results are obtained with projectiles manufactured in the new way.

It is worthy of remark that timber backing to iron plates has been set on fire by Palliser *shot* without bursting charges.

We may therefore sum up the conditions requisite for efficient firing at armour plating as follows:—

(1) The shot must strike the plating with the greatest energy attainable. It is obvious from what has been already stated that for piercing plates the diminution of calibre has certain advantages, and the calibre chosen for a certain weight of projectile must be selected from considerations similar to those that were discussed when treating of lowness of trajectory.

(2) The projectile should be of hard material—steel, or chilled iron.

(3) The ogival-pointed is the best form of head. It is now struck with a radius of $1\frac{1}{2}$ times the diameter of the shot.

(4) If the armour can be easily pierced by the gun that can be brought against it, very destructive effect will be produced by firing shell with a bursting charge without a fuze; but if the armour is very thick, a heavier blow is struck by a shot.

(5) At 200 yds., 7, 8, and 9-in. projectiles with the service charge will penetrate plates not more than 1 in. thicker than the diameter of the projectile. This will give a sort of guide to the relative power of guns and armour.

(6) The resisting power of plates to penetration is not much increased by elastic backing, but it is by rigid backing.

Against unarmoured vessels, the most efficient projectile will be a common shell, fired with a percussion fuze that will not act on graze on water, but will act on impact on the side of a wooden ship. They can be fired from the same guns that fire Palliser projectiles against iron-clads, or from smaller guns.

Coast batteries and fortifications are built either of iron, masonry, iron and masonry combined, or earth.

Iron forts require the same conditions for firing at them with effect as iron ships.

It has been found that masonry can be rapidly ruined by large iron or steel shot or shell, if a number of shots strike it fairly within a limited space at ranges from 600 to 1000 yds. But it would be very doubtful if in actual warfare sufficient accuracy and rapidity of fire could be brought to bear upon a fort by ships—the aim being disturbed by the smoke, not only of their own guns, but also of those of the fort; and if the embrasures in the fort are fitted with iron shields, the guns in the casemates would be able to keep up their fire for a considerable time after the masonry had begun to be ruined; so that if forts of this description were armed with heavy guns, it is very doubtful whether ships attacking them would not be obliged to haul off before they could silence the forts.

This is still more the case with iron forts with rigid backing to their armour-plates, which would probably be impregnable to ships, unless liable to have an overwhelming weight of fire brought upon them all round.

It is possible that it might be found that heavy spherical projectiles—such as are fired from the American S.B. ordnance—would have a greater effect against masonry than elongated shot or shell, from the shaking effect of their impact; but it must be remembered that ships would probably not be able to get within very short ranges of works of this nature, and at considerable ranges the accuracy of fire of smooth-

bore projectiles would be seriously impaired. Moreover, it would not be advisable to complicate the armament of a vessel for the sake of an advantage which could in any case be but slight.

Earthworks are best attacked by large shell with heavy bursting charges, which would ruin the parapets and block up the embrasures, if there were any, and dismount the guns if they struck them. The possibility of requiring to use large bursting charges must be taken into consideration when deciding on the calibre for our guns, so that the efficiency of the common shells may not be impaired by too great a diminution of the bore.

Shrapnel might also be used advantageously against boats or against earthworks, if the guns are so mounted as to expose the detachments.

It has been found that elongated projectiles will pass through a considerable thickness of water; and the subject is worth considering whether ships could be advantageously attacked by shot directed to pass through the water and strike them below the water-line. The conditions necessary for this to be done effectively, are that the shot must strike the water at an angle sufficiently great not to ricochet, but no greater than is unavoidable for this purpose, or it will pass below the ship's bottom. It must also strike within such a distance of the ship's side as that its path shall not pass under the ship's bottom. Many shots would have to be fired in all probability before one took effect, and experiments should be instituted to discover what chance there was of making a successful shot, so that the elements might be obtained for calculating the probability of this method of attack being more or less effective than direct fire at the part of a ship above the water.

Vertical fire against ships would also be very effective, if it were possible to attain sufficient accuracy; but at present in England we have no mortars whose fire could be calculated upon to hit a ship, although the recently approved 8-in. rifled mortar appears likely to supply the want.

Guns mounted in coast defences would have to be employed almost exclusively against shipping. The same conditions, therefore, apply to their projectiles as to those for ship guns.

The principal directions in which improvements may be looked for are—in the manufacture of Palliser projectiles, to render them more regular in their quality; and in fuzes, time and percussion, to render the burning of the time fuzes as regular and unvarying as possible, and to ensure the percussion fuze not acting on graze on water, but bursting on encountering the side of a wooden ship. Attention may also be directed to the most perfect adjustment of calibre to weight of projectile, so as to get the utmost amount of energy in the shot; and to the perfection of a system of rifling that shall ensure steadiness of flight in the projectile, so that its blow may be always direct.

We will now turn to artillery for fortresses and siege works.

II.—*Fortresses and Siege Works.*

The objects to be attained by the guns of a fortress are—to keep the besiegers at a distance from the place at the early stages of the investment, so that they shall be obliged to commence their works as far as

possible from the fortress; next, to render it difficult for the besiegers to construct and arm their batteries; and lastly, to keep down the fire of those batteries as long as possible. They have, moreover, to harass the troops covering the working parties, and to prevent the enemy from attempting a *coup de main*.

Common shell or shrapnel would be used to attain the first two objects, according to circumstances; shell being the most effective against earthworks that can be seen, and shrapnel against troops or working parties, in the open or behind partial cover.

When the enemy has succeeded in establishing his batteries and arming them, and has opened fire, the artillery of the place will endeavour to destroy his batteries and silence his guns. For this purpose common shells will generally be the most efficient projectiles. With large bursting charges, and a percussion or concussion fuze sufficiently sensitive to explode in newly turned earth, they will make large craters and holes in the parapets of the batteries, block up the embrasures, and dismount the guns. It must be remembered, however, that the besieger will not unmask his batteries and open fire until he has as many guns in position as he thinks will be sufficient to overpower the artillery fire of the place. The guns of the fortress must therefore be protected, as far as possible, by being mounted on Moncrieff carriages, or by iron shields to the embrasures, so that by their artificially provided advantages they may be made a match for the superior numbers of the besieger. The guns of the latter will labour under the disadvantage that they will not be able to be protected by iron, and that in all probability Moncrieff carriages will be unavailable, on account of the extra transport that their weight would render necessary. They would therefore have to be mounted either *en barbette*, or in embrasures unprotected by iron, or on high carriages with shallow embrasures; and in any of these cases they would be more exposed than the guns of the fortress. These should endeavour—by being ready to open fire as soon as the besiegers' batteries are unmasked, and having the advantage of the ranges being already accurately known—to prevent the fire of the besiegers from ever becoming superior to that of the defence; for if it ever does become so, the defenders can never regain a superiority, or even an equality, but they will gradually become more and more inferior, until their fire is so weakened that the besiegers can push forward their works, and the fall of the place becomes inevitable. Should the guns of the besiegers be muzzle-loaders, the gun detachments will be considerably exposed, whether the guns be mounted *en barbette* or in embrasures, and shrapnel may be fired at them with effect; which will enlist another element in favour of the defence, as their gunners would be less liable to loss in this way, even if their guns were also muzzle-loaders, as the opening of their embrasures might be made much smaller than those of the attack if a system of muzzle-pivoting were employed.

It is noteworthy that at the siege of Belfort some French guns firing at high angles without embrasures, and laid like mortars by means of pointing rods, caused more trouble to the Germans than any others, and were never silenced; whereas those firing through embrasures, whether protected by iron or not, were soon silenced.

In later stages of the siege, the artillery fire of the place must be so enfeebled that no rules can be laid down for its employment, except that every endeavour must be made to keep as many guns efficient and in action as possible, so as at all events to cause delay to the besiegers.

Next, with regard to the artillery of the siege train.

The first principle is, that the batteries must not be unmasked and fire opened until they have all been completed and armed, or at least a sufficient number to assert a decided superiority over the artillery of the place from the first.

Fire must be opened from all the batteries simultaneously, and as early in the morning of the day of opening as it is possible to see, so that the enemy may be taken unawares before his gunners are at their posts, and that a certain effect may be produced before a return fire can be commenced. Common shell with large charges would be fired against earthworks or ordinary masonry, and Palliser or steel projectiles against iron shields. It would probably be found that the gun detachments were too well protected for it to be advisable to fire shrapnel at them until some of the defensive works had been ruined by shot and shell. The ranges of the different works of the fortress from the batteries should be ascertained, as nearly as it may be possible to do so, from plans and maps which would be in possession of the staff and engineers, so that as little time as possible may be lost on opening before the fire becomes effective. The rate of firing should be laid down beforehand, and it is essential that it should be continuous, so that the defenders may have no time to repair damages, or bring up other guns in place of those that might be rendered ineffective.

The first batteries which the besieger makes will not be, probably, at a less distance than from 2500 to 3000 yds. from the place.

When the fire of the place has been subdued, the besiegers will push forward their trenches and construct their breaching batteries.

In old times, breaching batteries were established on the crest of the glacis of the work to be breached. With modern artillery, scarps can be breached from a distance, even though hidden from view, and the power of musketry fire has so increased that it will be generally impossible to establish breaching batteries in the former position, but they will generally be placed from 1000 to 1500 yds. from the place.

We will now consider the conditions under which a hidden revetment may be successfully breached by curved fire.

The object to be gained is that the projectile should graze the crest of the covering work, and strike the scarp wall at the desired point with the maximum of energy. The first thing to be done is to decide upon the gun and projectile to be employed.

It is required that a projectile should strike the revetment at a considerable angle of descent with sufficient energy to destroy the masonry. Now, in order that a considerable angle of descent may be obtained at a moderate range (from 1000 to 1500 yds.), it is necessary that the remaining velocity should be low; but this may be obtained in two ways—by a projectile that has been fired originally with a comparatively high velocity, and has lost it rapidly, or by a projectile that has been fired originally with a lower velocity and a higher elevation, but has not lost its velocity so quickly.

constructed, has its bursting charge at the base of the shell, and projects the bullets forwards so as to maintain a considerable velocity, and to continue to travel in the direction of the line of fire.

Segment shell are constructed of segments of iron built up into the form of a cylinder, with a solid head and base and an outer cylinder of thin sheet-iron. They were introduced to obviate the disadvantage that common shell were apt to break up only into a few large pieces, and it was also thought that, being opened by a small charge, the segments would continue to fly forward and act as shrapnel; but it has been found that they scatter too much, and that the segments are of a bad shape for flight, so that they are not efficient as shrapnel, and contain too small a charge of powder to be very useful as common shell against fieldworks or buildings, while shrapnel with an increased bursting charge and a percussion fuze are found to be nearly as effective against guns or wagons. Therefore I would recommend their being withdrawn from the service, and only shrapnel and common shell retained, with perhaps 3 to 5 rounds of case per gun.

Shrapnel is by far the most effective projectile against troops of all kinds under such cover as shelter-trenches, gun-pits, or woods. Shell are effective if they burst in the right place, but their effect is altogether lost if they do not do so, whereas shrapnel covers a large space of ground with its effects.

Against artillery, shrapnel has also the best effect; as the fire of a battery is quicker silenced by placing the men and horses *hors de combat* than by dismounting the guns themselves.

Against field works of good profile shrapnel would not be so efficient, as the parapets and bomb-proofs would give good cover, and shells would have to be used to ruin the parapets and dislodge the defenders. Shrapnel, however, might have a very good effect if fired at embrasures, if there were any, as the bullets passing through would be very destructive to the gun detachments.

Against obstacles, *abattis*, and stockades, common shell would be most efficient, as the body of the projectile would cut a way through them, even if it did not burst; and if it burst, it would destroy a considerable portion of the obstacle. They would of course be fired with percussion fuzes.

Against houses, villages, &c., common shell would be the most effective, to break down the walls and set on fire the houses.

There still remains a large field for improvement in the employment of field artillery, especially in the use of it against troops under cover. A method is required by which projectiles shall be thrown with tolerable certainty so as to fall a short distance inside the crest of the parapet of field works, and then act with destructive effect against the defenders of the works. We have no certain means of doing this at present, but it remains to be seen whether inventive genius will not be able to contrive a rifled mortar, or weapon of that nature, from which vertical fire may be obtained sufficiently accurate for the purpose, and mounted in such a way as to be capable of being formed into field batteries.

Improvements in fuzes also are desirable, as we are at present rather deficient in that way. Our time fuzes for muzzle-loading ordnance are fairly good, but there is no reason to despair of being able to improve

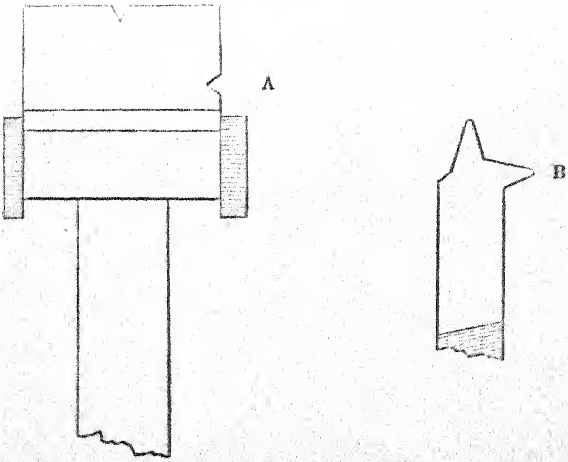
even them; but we have no time fuze for breech-loading ordnance that can be relied upon, and although it is true that the system of muzzle-loading has been approved for our service, yet there are certain advantages in a breech-loader—notably that of being able to have a powder chamber of larger calibre than the bore of the gun, and so being able to burn a large charge, and get a very high velocity with a short gun of small calibre—which might be found to make it advisable to use breech-loaders for certain purposes, and then the need would be found for a suitable fuze. We have not got everything we want in the way of percussion fuzes at present; we require a fuze that shall act on graze for land service, and that will act with certainty in newly-turned earth.

There is always a larger margin of error in the range of a projectile than in its lateral deviation, for two reasons.

(1) That a very small error in the elevation given, or in the laying, causes a considerable difference in the range; because the error acts in the direction of the flight of the projectile.

(2) Because in laying a gun it makes a considerable difference in the elevation, whether a full or fine sight is taken; and it is more difficult to get the fore-sight always in exactly the same position vertically in the notch of the tangent-sight, than it is to get it exactly in the centre horizontally. Moreover, it makes a difference in the laying of the gun, as regards elevation, whether the eye is placed close to the tangent-sight or a little way from it.

To get rid of these latter causes of error, I would propose that a second notch should be made on the tangent-sight, on its vertical edge, and a second edge made on the trunnion-sight; the second edge being in a horizontal plane, and so arranged that the line of sight through the second notch and second edge should be exactly parallel to that through the ordinary notch and edge. The arrangement proposed is shown roughly in the annexed figures.



TANGENT SCALE. TRUNNION SIGHT.

A, B.—The proposed new notch and sight.

With this arrangement, the laying could be as accurately done in a vertical direction as in a horizontal one. The second sight need not be used unless great accuracy were required, and time could be afforded to use it; but I think there can be no doubt that it might be found very useful in cases when it is of the essence of the success of the firing that no error should be made in the elevation given to the gun. It is probable that telescopic sights will be found very useful when deliberate but accurate fire is required.

So far we have only spoken of the material armament, and of the principles by which its use must be guided; but the personal part of the question must not be overlooked. The most perfect armament, and the most thorough mastery of principles, are of no avail, unless you have men trained to use the armament, and to put the principles into practice. The method by which men are to obtain this training, it is not my province to discuss now; I merely call attention to the matter to point out its vast importance, but hope to see it discussed in future essays of this series.

I have endeavoured, in the foregoing pages, to give a general view of the principles which regulate the efficiency of artillery projectiles under the varying circumstances in which they are required to be used, and to indicate the directions in which improvements may be sought. I cannot but feel how imperfectly I have succeeded; and in disclaiming all credit for originality, I wish to acknowledge my obligations to the works of Owen, Noble, and Hohenlohe-Ingelfingen, and to papers by various authors in the "Proceedings of the Royal Artillery Institution," the "Journal of the United Service Institution," and the "Professional Papers of the Corps of Royal Engineers."

ON CONSTRUCTION

OF

ELEVATOR, MONCRIEFF CARRIAGE.

BY

THE REV. J. WHITE, M.A.,

INSTRUCTOR IN MATHEMATICS, R.M. ACADEMY.

A POINT worthy of attention in the construction of the Moncrieff gun-carriage, is the form of the lower part of the elevators. This was originally, and still seems to be, a quadrant of a circle, with the common centre of gravity of the entire mass of the gun, counterweight, and elevators for its centre; or, to speak more exactly, with perpendicular horizontal projection of that centre of gravity on each elevator for its centre. However, it was found in this case that as the perpendicular from the point of support where the elevator rested on the rail passed through the centre of gravity, if the carriage was checked before the gun had run up into the firing position, it would not of its own accord resume its motion; or, as it was very difficult to find out exactly this common centre of gravity, sometimes the line of support passed in front of it, in which case the carriage was inclined to run back from the firing position. Thus there was a dead point, or a tendency to run back in some positions, if once checked in rising from the loading to the firing positions; and this was rather a serious inconvenience, as the breaks must be used to prevent its running up violently, and it required a considerable amount of labour to put so large a mass in motion again.

This inconvenience has been entirely overcome, in the following manner:—

Round the common centre of gravity, or rather its projection on each elevator, a small circle is drawn, and the apparently quadrantal part of the elevator is in reality an arc of the involute of this circle.* Consequently, the vertical from the point of support being a normal to this involute, always is a tangent to the circumference of this circle, and is therefore a uniform distance behind the common centre of gravity. The counterweight has, therefore, a uniform preponderance over the gun; or, to speak more exactly, the moment of the whole mass round the point of support—the "*moving fulcrum*"—is uniform.

The carriage, therefore, though checked at any point when rising from the loading to the firing positions, readily resumes its motion when the break band is relaxed.

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* The diameter of this circle is 6 ins. in the 18-ton gun-carriage, 4 ins. in the 12-ton, 3½ ins. in the 7-ton, 3 ins. in the 7-in. B.L. and in the 32 converted 64-pr. gun-carriage.

With this arrangement, the laying could be as accurately done in a vertical direction as in a horizontal one. The second sight need not be used unless great accuracy were required, and time could be afforded to use it; but I think there can be no doubt that it might be found very useful in cases when it is of the essence of the success of the firing that no error should be made in the elevation given to the gun. It is probable that telescopic sights will be found very useful when deliberate but accurate fire is required.

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March 31, 1873.

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* The diameter of this circle is 6 ins. in the 18-ton gun-carriage, 4 ins. in the 12-ton, 3½ ins. in the 7-ton, 3 ins. in the 7-in. B.L. and in the 32 converted 64-pr. gun-carriage.

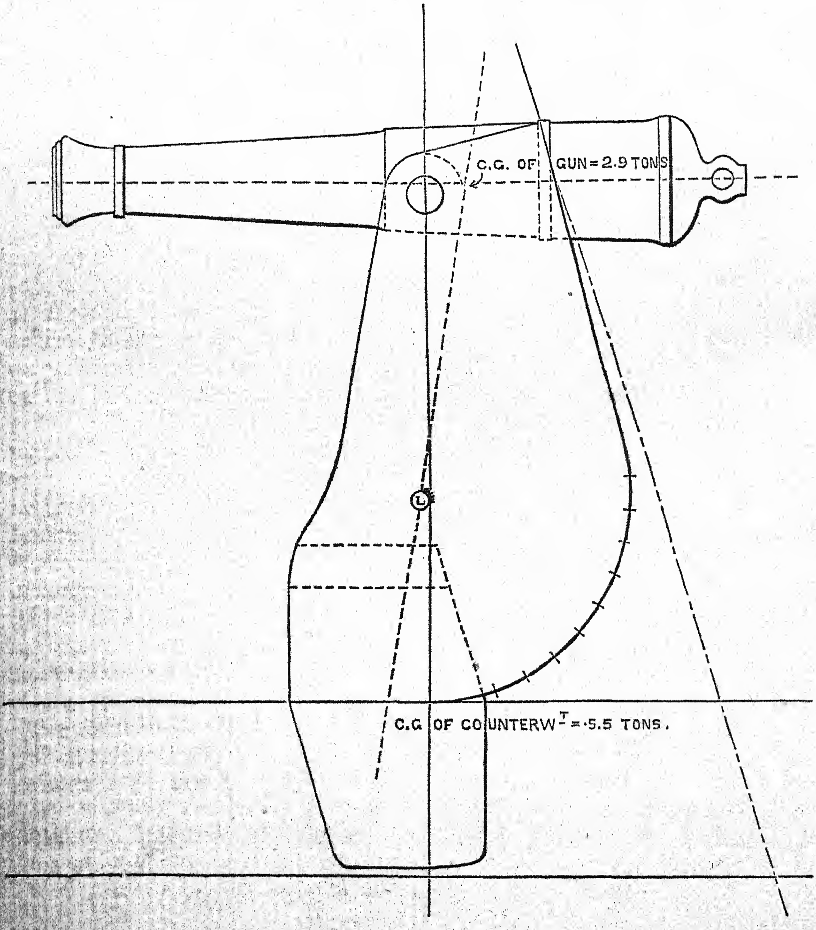
Another advantage gained is that *perfect* accuracy in finding the centre of gravity of the whole mass is not required. As long as it is anywhere inside the circumference of the small circle whose involute is taken, there will be no dead point in the motion of the elevators.

This margin of permissible error is of much practical utility.

It will be observed that these remarks do not apply to that part of the elevator which is meant to give the counterweight a rapidly increasing advantage over the gun, and so to subdue the recoil.

The tracing represents a Moncrieff carriage for a 32 converted 64-pr. gun. In it, *L* represents the small circle whose centre is opposite the common centre of gravity, and from which the arc of the involute is unwound. The marks on the outer side of the elevator correspond to the small marks on the circle, and shew the successive positions of the line in tracing the involute.

The problem solved may be thus stated:—In what form should a uniformly loaded rocker be cut that one end should have a constant moment over the other? The required form is that of an involute of a circle whose centre is the centre of gravity of the whole mass.



NOTE

ON

THE EXPENDITURE OF AMMUNITION

BY THE

GERMAN FIELD ARTILLERY

IN 1870-71.

BY

CAPTAIN HIME, R.A., F.S.S.

FROM the interesting discussions that took place after the lectures delivered by Capts. C. Jones and Sladen, R.A., on the 16th January and the 17th February, 1871, respectively, it is apparent that there is a party of officers in the regiment who consider that, if possible, the number of rounds at present carried in the gun-limbers should be increased, and that the increase in the weight behind the horses should be compensated for by removing the knapsacks, camp-kettles, carbines, &c., from the gun-carriages and limbers to the wagons, or elsewhere. As I belong to this party myself, it was with no small surprise I found, from letters from brother officers, that by publishing the average number of rounds per gun fired by the Germans, 1870-71, in "The German Artillery," ("Proceedings, R.A. Institution," Vol. VIII. p. 241), I am supposed to have given considerable support to the opposite party. The average number of rounds, it is said, in all the battles, is much below what might have been expected, and the figures on the whole show that our present supply of ammunition is amply sufficient for all practical purposes.

I hasten to correct the misunderstanding on which this conclusion is based.

If, as Napoleon said, every contingency in war must be provided for, the supply of ammunition for field guns should be based on the maximum, not the minimum, number of rounds they may be expected to fire in action. There are exceptional cases, of course, which no care or forethought can possibly meet; but the number of rounds available per gun ought undoubtedly to approach as nearly as possible to the maximum that would be required in the general run of cases. Now,

no reliable conclusion can be drawn as to this maximum from the average number of rounds per gun given in "The German Artillery." As I pointed out in the note appended to that paper, "in many instances the number of rounds fired was much less, and in others considerably more, than the average." In order that no misapprehension whatever may exist on this point, I shall give the maximum and the minimum number of rounds fired by some of the German batteries during 1870-71. My figures are taken, partly from the "Die Deutsche Artillerie in den Schlachten bei Metz," von Hoffbauer, Part I. pp. 51–52, Part II. pp. 111–13; and partly from the "Beiheft zum Militair-Wochenblatt," 1872, Zehntes Heft, pp. 319–51.

Wissemburg.

The total average was 15·5 rounds per gun.

No. 1 Light Field Battery, 5th Regt., Lower Schleswig Field Artillery, fired 33·3 rounds per gun. No. 3 Horse Artillery Battery, 11th Regt., Hessian Field Artillery, fired 5 rounds per gun.

Wörth.

The total average was 42·6 rounds per gun.

No. 3 Horse Artillery Battery, 5th Regt., Lower Schleswig Field Artillery, fired 112·6 rounds per gun; and 6th Light Field Battery of the same regiment fired 202·1 rounds per gun. No. 1 Horse Artillery Battery, 2nd Bavarian Field Artillery, fired 5 rounds per gun.

Spicheren.

The total average was 30·4 rounds per gun.

No. 1 Light Field Battery, 7th Regt., Westphalian Field Artillery, fired 85 rounds per gun. No. 4 Light Field Battery, 1st East Prussian Field Artillery, fired 3 rounds per gun.

Borny.

The total average was 20·7 rounds per gun.

No. 6 Light Field Battery, 1st East Prussian Field Artillery, fired 52·5 rounds per gun. No. 2 Heavy Field Battery, 9th Schleswig-Holstein Field Artillery, fired 4·3 rounds per gun.

Mars-la-Tour.

The total average was 94 rounds per gun.

No. 2 Light Field Battery, 3rd Brandenburg Field Artillery, fired 230 rounds per gun; No. 3 Horse Artillery Battery of the same regiment fired 191 rounds per gun; No. 2 Heavy Field Battery of the same regiment fired 180 rounds per gun; and No. 1 Horse Artillery Battery, 10th Hanoverian Field Artillery, fired 175 rounds per gun.

On the other hand, No. 2 Heavy Field Battery, Grand Ducal Hessian Artillery Corps, fired 6·3 rounds per gun; and No. 1 Light Field Battery of the same regiment fired 11·1 rounds per gun.

Gravelotte.

The total average was 56·5 rounds per gun.

No. 2 Light Field Battery, 9th Schleswig-Holstein Field Artillery, fired 184 rounds per gun; No. 2 Light Field Battery, Hessian Artillery Corps, fired 160 rounds per gun; No. 3 Horse Artillery Battery, 3rd Brandenburg Field Artillery, fired 142 rounds per gun; and other batteries fired 137, 136, 133, 126, 117, 115, and 108 rounds per gun.

But again, the guns of the 2nd Pommeranian Regiment fired 2 rounds per gun; and those of the 10th Hanoverian Regiment fired 17·3 rounds per gun.

Beaumont.

The total average was 30 rounds per gun.

No. 3 Horse Artillery Battery, 4th Magdeburg Field Artillery, fired 146 rounds per gun. No. 1 Horse Artillery Battery, 3rd Bavarian Field Artillery, fired 1·3 rounds per gun.

Noisseville.

The total average was 59·5 rounds per gun.

No. 2 Horse Artillery Battery, 1st East Prussian Field Artillery, fired 158 rounds per gun; and the 5th Heavy Field Battery of the same regiment fired 155 rounds per gun. The 18 guns of the Reserve of the 5th Army Corps fired 12 rounds per gun.

Sedan.

The total average was 55·8 rounds per gun.

No. 1 Horse Artillery Battery, 2nd Bavarian Field Artillery, fired 145 rounds per gun; and the 4th Heavy Field Battery, 12th Saxon Field Artillery, fired 132 rounds per gun. No. 9 Heavy Field Battery, Wurtemburg Field Artillery, fired 1·6 rounds per gun.

The foregoing figures are sufficient to show the value of the total average in estimating the maximum number of rounds required in action. Whether the number of rounds we carry at present is sufficient or insufficient, it is not for me to decide; but the whole question in dispute seems to me to turn rather upon the number of rounds in the gun-limber than upon that in the wagons, as was pointed out by Colonel R. Biddulph in the discussion that followed Captain Sladen's lecture.

GLASGOW,

July 21, 1873.

GRAPHICAL SOLUTION

OF

PROBLEMS ON ARTILLERY MACHINES.

BY

MAJOR W. H. WARDELL, R.A.,

INSTRUCTOR IN MATHEMATICS AND MECHANICS, R.M. ACADEMY.

It has been suggested to me that the graphical solution of the following simple problems—extracted from a pamphlet drawn up for the use of the Gentlemen Cadets of the Royal Military Academy—might prove of some interest to the regiment at large.

The convenience of this method will be evident if we compare the labour required to obtain numerical answers from some of the analytical expressions for the various strains, &c., with the simple process of constructing a diagram, and measuring off the results upon the scale used. This scale need not be a large one; the space afforded by a half-sheet of foolscap, together with the aid of a pencil and graduated rule, will enable us to ascertain the conditions of equilibrium, in any given case, with rapidity and great accuracy—in fact, the problem may be solved in much less time than is required to describe the process.

The mode of solution here indicated may be extended to particular questions which arise in the transport and mounting of heavy ordnance.

Analytical investigations of some of the following problems were, a few years since, published in these papers, which were cumbrous and not quite accurate; I have therefore thought it well to insert a short analytical solution in each case, dependent only on simple trigonometry and the most elementary principles of mechanics—avoiding altogether the use of co-ordinate axes.

Hydraulic Jack.

The hollow cylinder *LMNR* (Fig. 5), is raised by the water pressure upon the solid stand or piston *HKFG*, the roughened surface *LM*, or the projection at *R*, being placed beneath the weight to be lifted. A valve at *P* admits the water from the *upper* cistern to the passage underneath the plunger *DE*, and there is also a valve at *V*, supported by a spiral spring, which allows the water to pass into the *lower* cistern when the least pressure

is applied; Q is a screw which, when the weight is to be lowered, opens a passage for the water to return into the upper cistern.

	inches.
Total length of handle, AC	24
Effective length of "	22
Distance, BC, of fulcrum from pivot of plunger	1
Diameter of plunger, DE	$0\frac{3}{4}$
" piston, HK	$2\frac{1}{2}$

Then, we have by leverage,

$$\frac{P}{W}=\frac{1}{22};$$

by hydrostatic pressure,

$$\frac{P}{W}=\frac{\text{area of plunger}}{\text{area of piston}}=\frac{\pi\frac{9}{64}}{\pi\frac{25}{16}}=\frac{9}{100}.$$

Therefore, for total advantage gained,

$$\frac{P}{W}=\frac{9}{2200}.$$

Hence, by a power exerted on the handle of a little over 90 lbs. we can obtain a lifting force of 10 tons—which is the greatest weight this machine is constructed to raise.

We have neglected the friction of the water-collars, which, however, is quite trifling compared with the loss by friction in the screw-jack; the latter will not raise nearly so great a weight, although it appears the more powerful instrument when friction is neglected.

Triangle-Gyn.

Let AD, BD, CD (Fig. 6), represent the three spars or "legs" of a triangle-gyn, bolted together at D, and so placed on the ground that their feet form an equilateral triangle, ABC.

Prob.—*To find the horizontal force required to keep the foot of each spar from sliding, the normal reaction, and the whole pressure on the ground.*

It is evident, from the symmetry of their positions, that the conditions of equilibrium of each of the three legs of the gyn are the same; let us, therefore, consider the case of the spar AD.

Let $l =$ length of each leg.
$a =$ distance between the feet,
$\angle\, \alpha =$ angle of inclination of each leg to the vertical,
$W =$ weight of gun and tackle,
$N =$ normal reaction of the ground at each foot,
$F =$ horizontal force (however applied) keeping each foot in position.
$R =$ resultant, or whole pressure on the ground.

Bisect BC in the point E, join AE, and draw AZ vertical; then the spar AD lies wholly in the vertical plane EAZ.

Now, if we neglect the weight of the spar (or if we assume half its weight to act at either end), the leg AD is kept in equilibrium by two sets of forces acting at its extremities, A and D; and hence the two resultants of these sets of forces act along the spar, and are equal in magnitude, each being R, but opposite in direction.

Then we may consider the foot A to be kept at rest by the action of three forces—viz., N acting along the vertical AZ, R acting in the direction DA, and a horizontal force F. Since the lines of action of two of these forces, N and R, lie in the vertical plane EAZ, the third force must also act in that plane—that is, along the line AE, its intersection with the horizontal plane. It is plain that R will be equal and opposite to the resultant of N and F; also that, resolving vertically, we get

$$3N = W, \text{ or } N = \frac{W}{3} \quad \ldots\ldots\ldots\ldots \quad (1)$$

If we take into account the weight of each spar (w) we have

$$3N - \frac{3w}{2} = W + \frac{3w}{2},$$

$$\text{or } N = \frac{W}{3} + w.$$

If H be the point in which the vertical let fall from D cuts AE, we have the sides of the triangle DAH—viz., DA, AH, and HD—proportional to the three forces R, F, and N respectively.

We can readily find F and R, either by construction or by analysis.

I. *Graphically.* (Fig. 7).

Construct to some convenient scale the equilateral triangle ABC of side (a). Bisect BC in E, join AE, and take $AH = \frac{2}{3}AE$; at H erect a perpendicular to AE, and set off from A along the perpendicular, $AD = l$. Then $\angle ADH = \alpha$, and the three forces keeping the foot of the spar at rest are proportional to the sides of the triangle DAH.

To find F and R, measure off from D along the perpendicular DH produced, $DK = N = \frac{W}{3}$ lbs. on any convenient scale, and draw KL parallel to HA, to meet the side DA produced in L; then, on the same scale, KL will represent the force F, and DL the resultant pressure R.

Or, we may measure off $D'K' = \frac{1}{3}W$ (Fig. 8) from D' along *any* line parallel to DH, and through D' and K' draw lines respectively parallel to DA and HA.

II. *Analytically.* (From Fig. 6, or Fig. 7).

$$\frac{F}{N} = \frac{AH}{DH},$$

$$\therefore F = N \cdot \tan\alpha = \frac{W}{3}\tan\alpha; \quad \ldots\ldots\ldots\ldots \quad (2)$$

$$\frac{R}{N} = \frac{AD}{DH},$$

$$\therefore R = \frac{N}{\cos\alpha} = \frac{W}{3}\sec\alpha. \quad \ldots\ldots\ldots\ldots \quad (3)$$

It will, however, be more convenient to express F and R in terms of the length of each spar, and the distance between their feet.

$$\sin \alpha = \frac{AH}{AD} = \tfrac{2}{3} \cdot \frac{AE}{AD} = \tfrac{2}{3} \cdot \frac{a \sin 60^\circ}{l} = \frac{a}{\sqrt{3} \cdot l};$$

whence

$$\tan \alpha = \frac{a}{\sqrt{3l^2 - a^2}}; \text{ and } \sec \alpha = \frac{\sqrt{3} \cdot l}{\sqrt{3l^2 - a^2}};$$

therefore we have

$$F = \frac{W}{3} \cdot \frac{a}{\sqrt{3l^2 - a^2}}; \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (4)$$

$$\text{and } R = \frac{W}{\sqrt{3}} \cdot \frac{l}{\sqrt{3l^2 - a^2}}. \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (5)$$

Sheers.

Prob.—*In sheers, to find* (1) *the tension of the back guy;* (2), *the horizontal force required to keep the feet from sliding;* (3), *the normal reaction at the foot of each spar;* and (4), *the whole pressure on the ground.*

AD, BD (see Fig. 10), are the spars, lashed together at D; DH represents the line of action of the back guy, taken in the vertical plane DCH, perpendicular to DAB, the plane of the sheers; then the intersection DO of these planes bisects the fixed angle ADB, and the centre of gravity of the weight W will also lie in the plane DHC, as it will be in the vertical through D. The feet A and B are securely lashed to pickets.

Let $l =$ effective length of each spar,
$W =$ weight of gun and main tackle,
$w =$ weight of each spar,
$\angle\, 2\alpha =$ inclination of spars to one another,
$\angle\, \theta =$ inclination of OD, axis of sheers, to horizon,
$\angle\, \phi =$ inclination of rear guy to horizon,
$F =$ horizontal force (however applied) required to keep each foot from sliding,
$N =$ normal reaction at foot of each spar,
$R =$ resultant, or whole pressure on the ground at foot of each spar,
$T =$ tension of back guy.

Whether we neglect the weight of the spars, or consider $\frac{1}{2}w$ to act at either extremity, it is evident that the apex D may be considered as kept at rest by three forces acting in the plane DHC—viz., W, T, and a force equal and opposite to their resultant, and whose line of action must lie in OD produced, and which force is plainly the sum of the resolved parts of the two equal forces, R, acting along AD and BD.

Again, the foot A is at rest through the action of three forces—N, F, and R. Of these, N acts vertically at A, R acts along the line DA (see Triangle Gyn), and both lie in the plane DAC; hence the third force F must also act in that plane—that is, along the line AC, its intersection with the horizontal plane. Similarly, the corresponding force F at B will act in the line BC.

Draw a vertical from O, meeting the line HD in K; then it is evident that DK, KO, OD, the sides of the triangle DKO, taken in order, are proportional to the forces which keep D at rest. Also that the sides DA, AC, CD, of the triangle DAC are respectively proportional to the three forces R, F, and N, which keep the foot A at rest.

I. *By Construction.* (See Figs. 11 and 12).

Given the length of each spar, the weights, the distance between the end of rear guy and feet of sheers, and the distance from feet to the vertical through centre of gravity of weight.

Having chosen some convenient scale, we must first find the length of OD, the axis of the sheers, which is best done separately. In Fig. 11, take oa, half the distance between the feet of the spars, draw od perpendicular to it, and from a, set off along the perpendicular a length ad equal to l; this gives us od.

Then, in Fig. 12, starting with a horizontal line, mark off HO, the distance between end of back guy and the feet of the sheers, O being the bisection of the space between the feet; set off OC, the distance measured from O to the foot of the vertical through the centre of gravity of the weight; at C erect a perpendicular to the horizontal line, and set off from O along this perpendicular the length OD already found, thus getting the inclination of the sheers. If this angle be already known or given, Fig. 11 is not required, for we can find the length of OD by drawing OA at right angles to OD, measuring along it the semi-distance between the feet, and setting off l from A along OD; then let fall the perpendicular DC upon the horizontal line. In either case, the triangle OAD must be described.

Join DH, draw OK vertical, and along OK, or OK produced, set off OK', representing on any convenient scale the number of cwt. in $(W + w)$, and through K' draw a line parallel to KD, meeting OD produced in D'; then $K'D'$ and $D'O$ give, on the same scale, the tension T, and the counterbalancing force along OD. Bisect $D'O$ in M, and draw MG parallel to DA; then MG represents the force R, $D'O$ being $2R$ resolved along the axis of the sheers.

To find N and F, we have the triangle DAC, which, however, lies in a place oblique to that of the paper, so that to get its proper dimensions we must *turn it down*, about DC as an axis, upon the plane of the paper. We can do this by describing an arc of a circle, with centre D and radius l, or DA, which cuts the horizontal line in A'. Join $A'D$, then the triangle $DA'C$ gives the *actual* magnitude, according to scale, of the triangle DAC. Set off from D along DA', produced if necessary, DS, representing to scale the number of cwt. in R, and through S draw SL parallel to $A'C$, meeting DC, or DC produced, in L; then SL, LD, are respectively equal to the forces F and N upon the scale chosen.

II. *Analytically.* (From Fig. 10, or Fig. 12).

From the triangle DKO,

$$\frac{T}{W} = \frac{KD}{KO} = \frac{\sin DOK}{\sin KDO};$$

$$\therefore\ T = \frac{W \cos \theta}{\sin (\theta - \phi)}. \quad \text{.................................} \quad (1)$$

Again,

$$\frac{2R \cdot \cos\alpha}{W} = \frac{DO}{KO} = \frac{\sin DKO}{\sin KDO}$$

$$= \frac{\cos\phi}{\sin(\theta - \phi)};$$

$$\therefore \quad R = \frac{W}{2} \cdot \frac{\cos\phi}{\cos\alpha \cdot \sin(\theta - \phi)}. \quad \ldots\ldots\ldots\ldots\ldots \quad (2)$$

From the triangle DAC,

$$\frac{F}{R} = \frac{AC}{AD} = \frac{\sqrt{l^2 - DC^2}}{l}$$

$$= \frac{\sqrt{l^2 - l^2\cos^2\alpha \sin^2\theta}}{l};$$

$$\text{since } DC = DO \sin\theta = l \cos\alpha \sin\theta;$$

$$\therefore \quad F = R\sqrt{1 - \cos^2\alpha \cdot \sin^2\theta}$$

$$= \frac{W}{2} \frac{\cos\phi \sqrt{1 - \cos^2\alpha \cdot \sin^2\theta}}{\cos\alpha \cdot \sin(\theta - \phi)}$$

$$= \frac{W}{2} \frac{\cos\phi \sqrt{\sec^2\alpha - \sin^2\theta}}{\sin(\theta - \phi)}. \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (3)$$

Also,

$$\frac{N}{R} = \frac{DC}{DA} = \frac{l \cos\alpha \sin\theta}{l};$$

$$\therefore \quad N = R \cos\alpha \sin\theta$$

$$= \frac{W}{2} \frac{\sin\theta \cdot \cos\phi}{\sin(\theta - \phi)}. \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (4)$$

We can approximate to greater accuracy by writing $(W + w)$ for W in the values for T, R, and F—as we may suppose $\frac{w}{2}$ to act at A or B—and we have

$$N - \frac{w}{2} = R \cos\alpha \sin\theta;$$

$$\therefore \quad N = \frac{W + w}{2} \cdot \frac{\sin\theta \cos\phi}{\sin(\theta - \phi)} + \frac{w}{2}. \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (5)$$

The above expressions may also be obtained by referring the forces acting on the sheers to OC, OA, and OK, as co-ordinate axes of x, y, and z respectively. We can resolve along OC and OK, and take moments about OA or BA. The method employed above is, however, simpler.

Lever Sheers.

Lever sheers consist of a long heavy spar, AH (see Fig. 13), with one end resting on the ground, and the other supported on two short spars, crossed and securely lashed together.

Let $W =$ weight of gun and tackle,
$L =$ length of spar AH,
$l =$ length AD, projecting beyond the point of support,
$a =$ radius of spar,
$\angle \alpha =$ inclination of spar AH to horizon,
$R =$ normal reaction at end H.

The strain caused by the weight suspended from A, acting vertically, may be resolved into two forces—(1) AB, at right angles to the spar, tending to break it across, and also to cause the other end H to fly up; (2) the force BC, acting in a direction parallel to the spar, and tending to force the end H into the ground.

It is evident that the triangles BAC, DEH are similar.

From the triangle BAC,

$$AB = AC \,.\, \cos BAC$$
$$= W \,.\, \cos \alpha. \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

Also, by the principle of the lever,

$$R = AB \,.\, \frac{AD}{DH} = W \cos \alpha \, \frac{l}{L}. \quad \ldots\ldots\ldots\ldots \quad (2)$$

To find the load which the spar will safely bear—from Fenwick's "Mechanics of Construction," p. 63—we have

$$Pl = \tfrac{1}{4} S\pi a^3, \text{ or } P = \frac{S\pi a^3}{4l};$$

where P is the "breaking weight." If μ be the ratio of "safe load" to "breaking weight,"

$$W \cos \alpha = \mu \, \frac{S\pi a^3}{4l}. \quad \ldots\ldots\ldots\ldots\ldots \quad (3)$$

The butt end of the spar AH is heavily weighted, and is usually sunk a little in the ground, resting against a board or slab of wood, to prevent the earth from yielding to the pressure of the force represented by BC. A rear guy is also employed, to prevent the short cross spars, or sheers, from falling to the front; the pressure of the lever at D prevents them from inclining to the rear.

Derrick.

If time and materials are available, a derrick should be constructed as follows:—One large spar or square beam is placed vertically, passing through a horizontal slab of wood, and sunk several feet in the ground. In the slab, which is further fastened to the beam by cleats, a hollow is made to receive the foot of the spar forming the derrick, the top of which is attached to that of the main beam by tackle. One or two guys are needed, to control the head of the derrick; the main beam is also supported by guys—one directly in rear, and at least one on each side.

In the following investigation, we shall suppose the tensions of the side guys to be resolved along the plane of the paper, taken as the vertical plane

through the derrick, main beam, and rear guy. If they are situated in a plane perpendicular to the plane of the paper, there will, of course, be no resolved parts in that plane.

PROB.—*To determine the strains upon the various parts of a derrick with main beam.* (Fig. 14).

Let $W =$ weight of gun and lifting tackle,
$a =$ effective length of main beam,
$l =$ " " derrick,
$t =$ tension of head tackle BC,
$T =$ tension of rear guy BH (including resolved portions, if any, of side guys),
$\angle\, \theta =$ inclination of derrick to the horizon,
$\angle\, \phi =$ " rear guy "
$N =$ normal pressure along main beam AB,
$R =$ resultant pressure along derrick AC.

Now, if we suppose the directing guys upon the head of the derrick merely to steady it laterally, the point C may be considered in equilibrium through the action of the forces W, R, and t; and since the lines of application of these forces are parallel to the sides BA, AC, CB, of the triangle BAC, those sides may be taken as respectively proportional to the forces. Again—since the point B may be taken as kept at rest by the three forces T, t, and N—if through A we draw AK parallel to BC, it is evident that the three forces are proportional to the three sides BK, KA, AB, of the triangle ABK, taken in order.

I. *To find the above forces by construction.*

We can easily obtain a diagram of the strains upon the derrick. (See Fig. 15).

Draw a line vertical and therefore parallel to AB, and set off from any point a in this line ab representing W on any convenient scale; through a and b draw lines parallel to AC and BC respectively; through b draw bk parallel to the direction of the rear guy BH, and draw ck vertical; then, upon the same scale, bc and ac will represent t and R, while bk and kc give us T and N.

We observe from the diagram that the force R is invariable for the same value of W, that the tension t diminishes as the inclination (θ) of the derrick increases; the tension T also varies inversely as θ, but directly as the inclination (ϕ) of the back guy; N decreases as θ is increased, but increases with ϕ.

II. *Analytically.* (Fig. 15).

From the triangle abc,

$$bc = \sqrt{a^2 + l^2 - 2al \sin\theta},$$

$$\frac{R}{W} = \frac{ac}{ab} = \frac{l}{a},$$

$$\therefore\ R = \frac{Wl}{a}; \quad \dots\dots\dots\dots \quad (1)$$

$$t = W \cdot \frac{bc}{ab} = \frac{W}{a}\sqrt{a^2 + l^2 - 2al \sin\theta}. \quad \dots\dots \quad (2)$$

From a draw ad parallel to bk, meeting kc produced in d. Then,

$$kc = kd - cd$$

$$= ab - \frac{ca \cdot \sin cad}{\sin adc},$$

$$\therefore \quad N = W - R \cdot \frac{\sin(\theta - \phi)}{\cos \phi}$$

$$= W\left\{1 - \frac{l \cdot \sin(\theta - \phi)}{a \cos \phi}\right\} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (3)$$

Also from the triangle adc,

$$\text{since } bk = ad,$$

$$\text{and } ad = \frac{ac \cdot \sin acd}{\sin adc},$$

$$\text{we have } T = \frac{R \cdot \cos \theta}{\cos \phi} = \frac{Wl \cos \theta}{a \cos \phi}. \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (4)$$

The above may also be found by taking moments round B (Fig. 14), and resolving horizontally and vertically. We have here neglected the weight of the spar forming the derrick, but it can be taken in account by supposing half its weight to act at either end, as in the case of the sheers.

When there is not time, nor sufficient timber at hand to erect a proper derrick, a single spar may be used. (See Fig. 16). If we draw AK vertical, the sides of the triangle ABK will evidently be proportional to the three forces keeping the point B at rest. There must be several side guys in this case, but by resolving all the tensions parallel to the plane of the paper, and then along the line BH, we can reduce the forces to three.

January, 1873.

Fig 4.

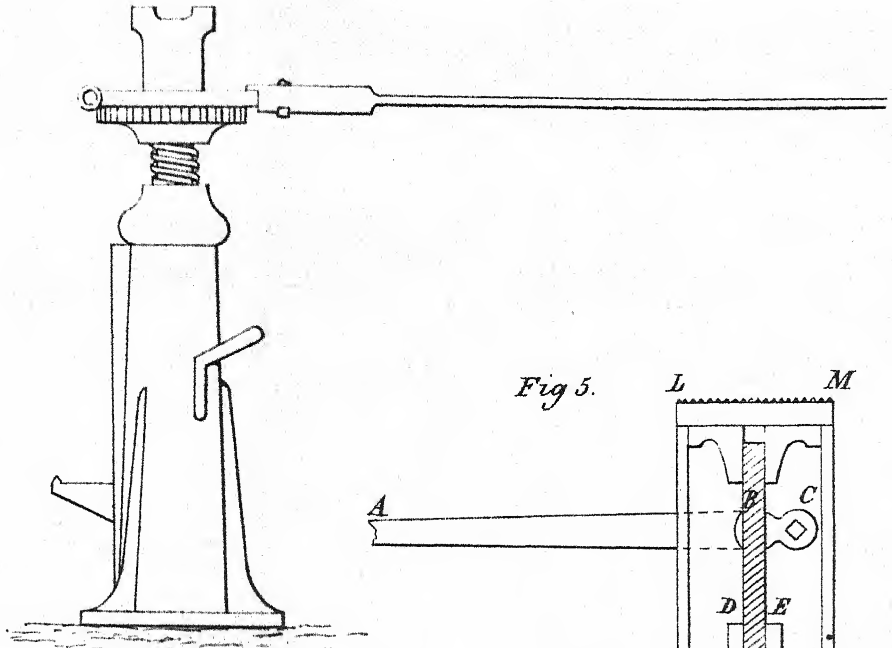


Fig 5.

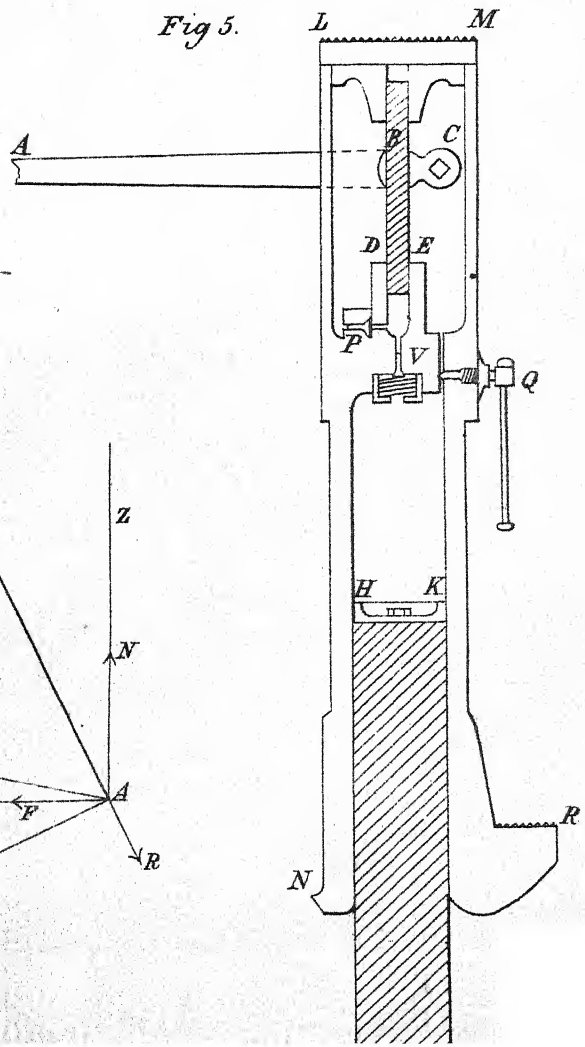


Fig 6.

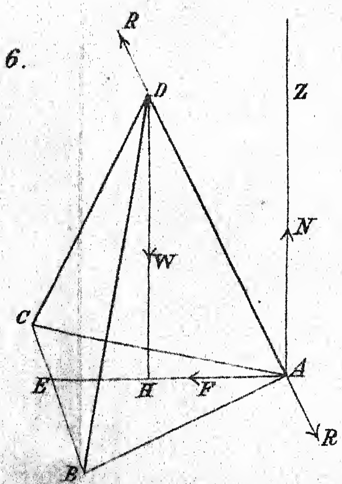
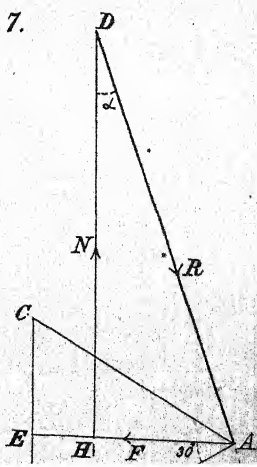


Fig 7.



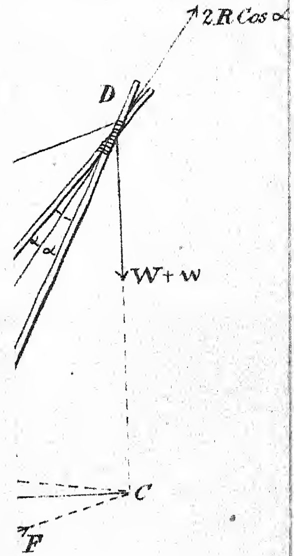


Fig 8.

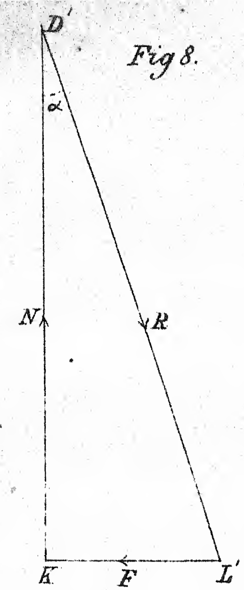


Fig 10.

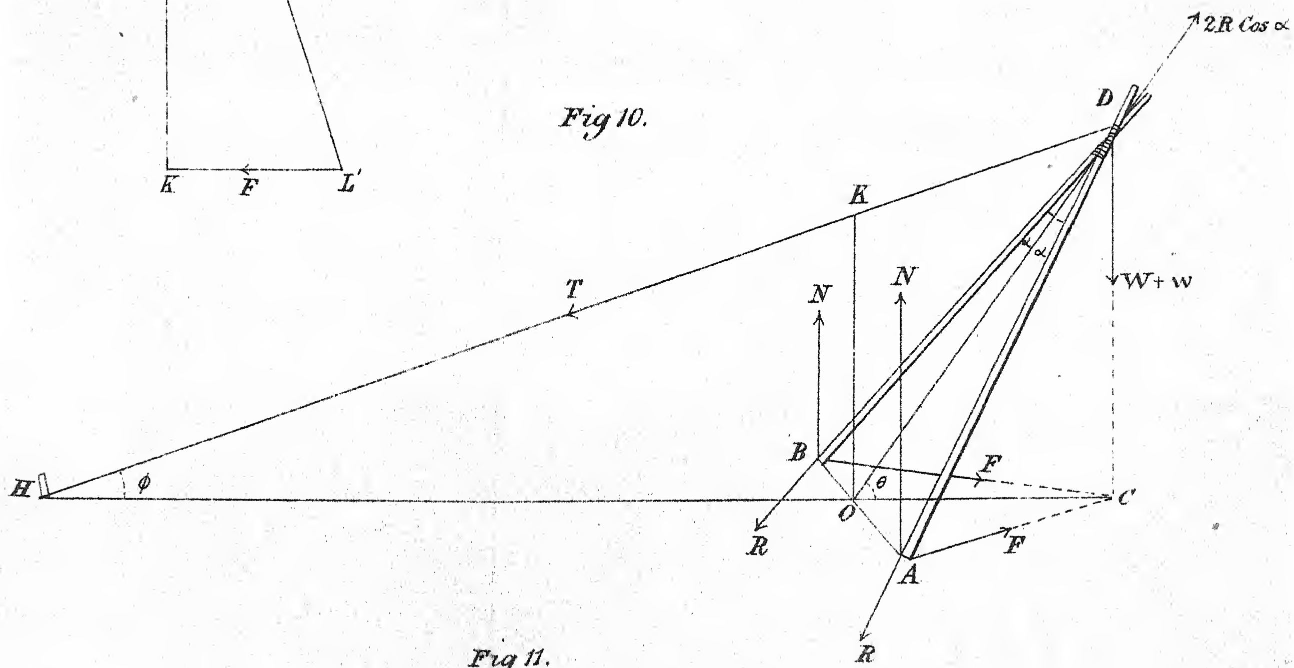


Fig 11.

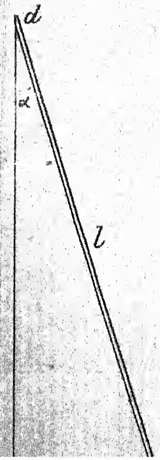


Fig 12.

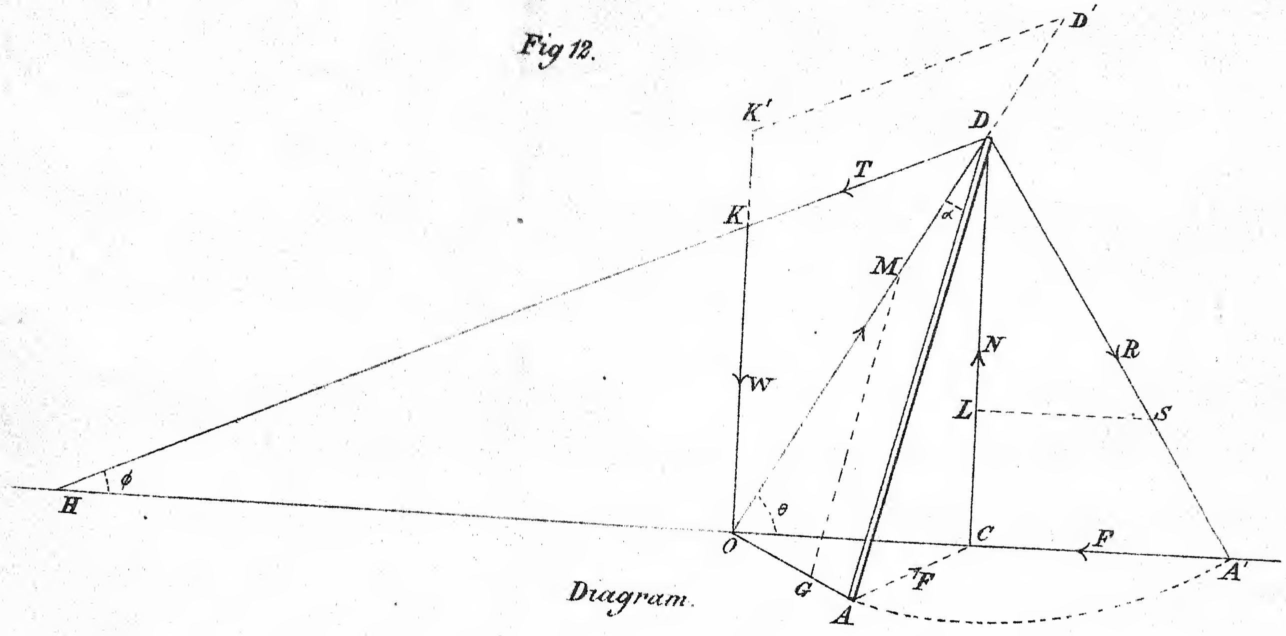
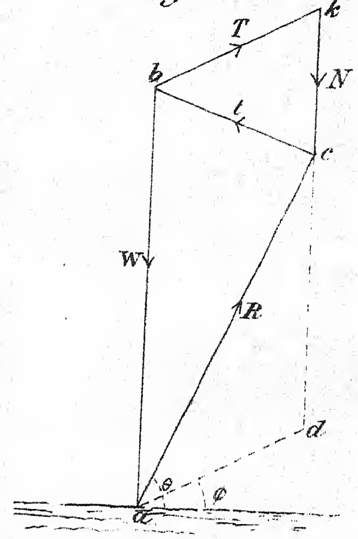


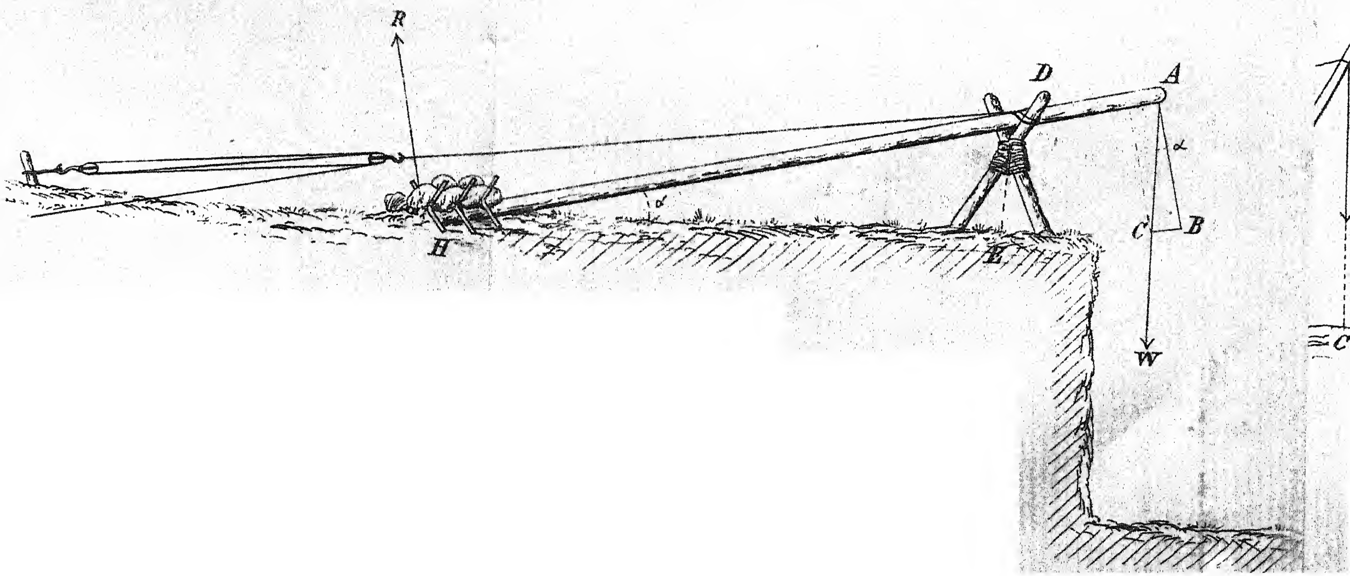
Diagram.

Fig 15.



Diagram

Fig 13.



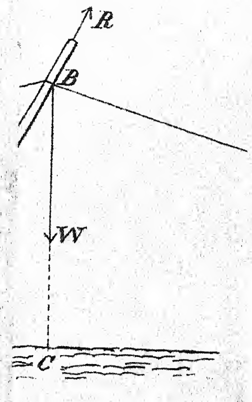


Fig 14.

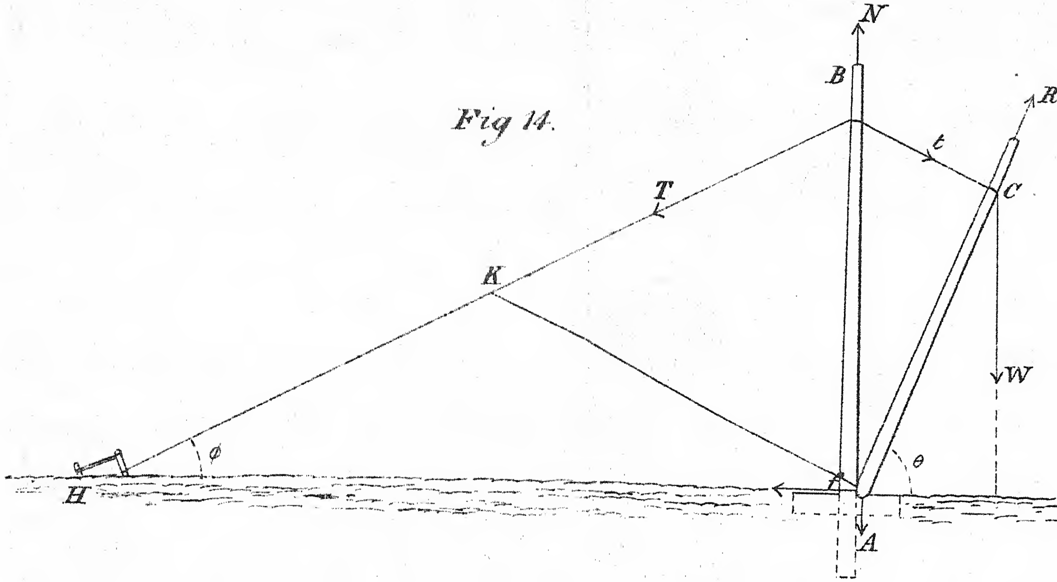
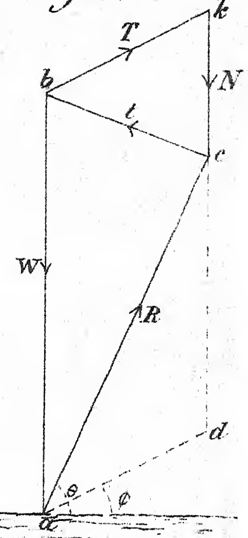
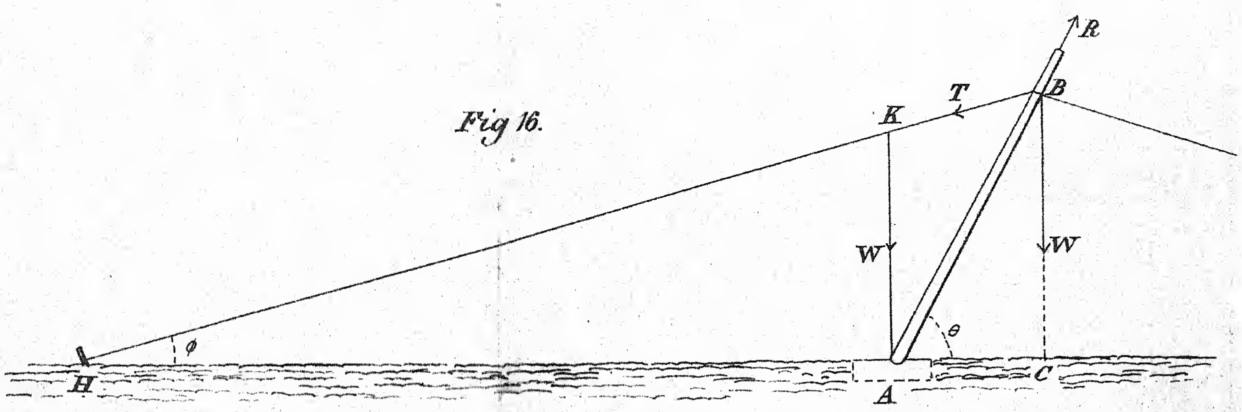


Fig 15.



Diagram

Fig 16.



105. Continuation of the Plan for carrying the Detachments with Field Artillery. (*Vide* "Short Notes," p. 157).

(Communicated by Major S. Penny, R.A.)

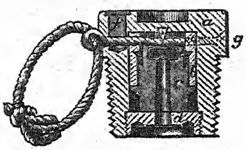
In consequence of having learnt that the present weight behind the team cannot be exceeded, I propose as follows :—

1. That the amount of ammunition equivalent to the contents of two axletree boxes be taken away from the gun-limber. This will reduce the weight on the shaft horse.

2. If the axletree boxes are not increased in size, as proposed, then to increase the lids only, both in front and rear, to allow of two men being carried on each axletree box.

106. Royal Laboratory Screw Percussion Fuze, G.S. (General Service).

(Communicated by Captain J. Sladen, R.A.)



a.	Body.	*e.*	Cap.
b.	Guard.	*f.*	Lead plug.
c.	Pellet.	*g.*	Safety pin.
d.	Bottom.	*h.*	Needle.

This fuze will act equally well from B.L. or M.L. rifled guns. Its use will probably be extended to the 40, 64-pr., and 7-in. B.L. guns, and up to 80-pr. M.L.R.

It is used with common, segment, or shrapnel shells, and will act either on graze or impact. It is tapped with a screw thread to fit the G.S. gauge of fuze hole.

Its construction is given in the engraving, and also the names of the several parts of the fuze.

The body, guard, and bottom plug are made of gun-metal, the pellet of lead and tin, the cap of copper, and the safety pin of twisted brass wire.

The head of the body is pierced to receive the safety pin; the lead plug serves to close the hole left when the safety pin is withdrawn. The safety pin is prevented from dropping out by twisting the ends of its wire outwards, as shown in the engraving. The hole at this end of the pin is covered by a strip of metal, soldered on. A loop of cord is attached to the safety pin, in order that it may be withdrawn easily. A needle point is fixed in the centre of the head, above the cap in the pellet.

The guard is a gun-metal collar, having two holes through which the safety pin passes, so as to keep it in position.

The pellet has a cap fixed in its head containing a large charge of cap composition (fulminate of mercury, sulphide of antimony, and chlorate of potash), protected by a very thin piece of sheet brass. On the exterior of the pellet are two projecting feathers, on which the guard is supported when the safety pin is withdrawn.

The bottom plug screws into the body, and has a central hole, closed by a thin brass disc.

The fuze is screwed into the shell by the G.S. key, which fits into the slot in the head. The safety pin is withdrawn just before the shell is placed in the bore of a B.L. gun, and in the case of a M.L. gun when the shell is placed in the bore.

Action.—On the shock of discharge the guard sets back, shearing off the two feathers, and fastens on to the pellet, the metal of the latter expanding into the undercut recess shewn in the guard. The lead plug prevents the flash of the discharge from entering the fuze through the safety pin hole. On graze or on impact—as the case may be—the pellet and collar fly forward, the cap is exploded by striking against the needle point, and the flash from cap blows out the disc closing the bottom plug, and explodes the shell.

107. Fuze, Time, Wood, R.M.L. Ordnance.

(Communicated by Captain J. Sladen, R.A.)

Mark III. will be sealed for future manufacture, differing from II. in the head projecting farther from the shell, in having a larger groove containing more priming, and in having a copper band. The paper lining will be reduced in thickness, and the powder channels will be so placed as to be midway between the composition channel and exterior, and reduced 1 in. in length.

This pattern is found more certain of ignition than Mark II., and is also less liable to cause prematures with heavy charges, owing to the powder channels being well protected.

ON

THE EMPLOYMENT OF ARTILLERY.*

COMMUNICATED BY

LT.-COL. W. E. M. REILLY, C.B.

I.—*General Principles.*

1. There are occasions when it would be wrong to employ artillery fire preparatory to an engagement—for instance, when the enemy is suddenly met with in such an unprepared state that he can be dispersed or captured by cavalry or infantry; when a defile, village, &c., has to be seized which is only weakly or hurriedly guarded by the enemy, but towards which a stronger body of his troops is advancing; and other cases.

2. The fault of insufficiently cannonading a well posted enemy with artillery fire, or of executing partial attacks with cavalry and infantry without sufficient preparation, has been a more common one. Such mistakes cannot fail to have a disadvantageous influence, not only upon the arms themselves, but on the whole engagement.

Military history shows that these errors have been most frequently committed by cavalry, especially in attacking squares of unbroken infantry before a previous effective cannonade with artillery, and that they have always been attended with repulse and heavy loss; consequently artillery—especially horse artillery—must always be on the look out, and be quickly at hand when wanted, in order to preserve the cavalry from failure in its attack.

The moments during which large bodies of hostile cavalry can be cannonaded with advantage are very short; because cavalry is best able to withdraw rapidly out of fire of the guns. But wherever we can use our artillery with effect, either by watching the opportunity, by advancing under cover, or by rapidity of movement, &c., our cavalry will have the best chances of victory in its subsequent attack.

3. In order that artillery may be at all times ready to open the introductory cannonade of the engagement, it is essential that it be

* Translated from General v. Hindersin's Memo., "Ueber den Gebrauch der Artillerie," by Captain F. C. H. Clarke, R.A.

The head of the body is pierced to receive the safety pin; the lead plug serves to close the hole left when the safety pin is withdrawn. The safety pin is prevented from dropping out by twisting the ends of its wire outwards, as shown in the engraving. The hole at this end of the pin is covered by a strip of metal, soldered on. A loop of cord is attached to the safety pin, in order that it may be withdrawn easily. A needle point is fixed in the centre of the head, above the cap in the pellet.

The guard is a gun-metal collar, having two holes through which the safety pin passes, so as to keep it in position.

The pellet has a cap fixed in its head containing a large charge of cap composition (fulminate of mercury, sulphide of antimony, and chlorate of potash), protected by a very thin piece of sheet brass. On the exterior of the pellet are two projecting feathers, on which the guard is supported when the safety pin is withdrawn.

The bottom plug screws into the body, and has a central hole, closed by a thin brass disc.

The fuze is screwed into the shell by the G.S. key, which fits into the slot in the head. The safety pin is withdrawn just before the shell is placed in the bore of a B.L. gun, and in the case of a M.L. gun when the shell is placed in the bore.

Action.—On the shock of discharge the guard sets back, shearing off the two feathers, and fastens on to the pellet, the metal of the latter expanding into the undercut recess shewn in the guard. The lead plug prevents the flash of the discharge from entering the fuze through the safety pin hole. On graze or on impact—as the case may be—the pellet and collar fly forward, the cap is exploded by striking against the needle point, and the flash from cap blows out the disc closing the bottom plug, and explodes the shell.

107. Fuze, Time, Wood, R.M.L. Ordnance.

(Communicated by Captain J. Sladen, R.A.)

Mark III. will be sealed for future manufacture, differing from II. in the head projecting farther from the shell, in having a larger groove containing more priming, and in having a copper band. The paper lining will be reduced in thickness, and the powder channels will be so placed as to be midway between the composition channel and exterior, and reduced 1 in. in length.

This pattern is found more certain of ignition than Mark II., and is also less liable to cause prematures with heavy charges, owing to the powder channels being well protected.

ON

THE EMPLOYMENT OF ARTILLERY.*

COMMUNICATED BY

LT.-COL. W. E. M. REILLY, C.B.

I.—*General Principles.*

1. There are occasions when it would be wrong to employ artillery fire preparatory to an engagement—for instance, when the enemy is suddenly met with in such an unprepared state that he can be dispersed or captured by cavalry or infantry; when a defile, village, &c., has to be seized which is only weakly or hurriedly guarded by the enemy, but towards which a stronger body of his troops is advancing; and other cases.

2. The fault of insufficiently cannonading a well posted enemy with artillery fire, or of executing partial attacks with cavalry and infantry without sufficient preparation, has been a more common one. Such mistakes cannot fail to have a disadvantageous influence, not only upon the arms themselves, but on the whole engagement.

Military history shows that these errors have been most frequently committed by cavalry, especially in attacking squares of unbroken infantry before a previous effective cannonade with artillery, and that they have always been attended with repulse and heavy loss; consequently artillery—especially horse artillery—must always be on the look out, and be quickly at hand when wanted, in order to preserve the cavalry from failure in its attack.

The moments during which large bodies of hostile cavalry can be cannonaded with advantage are very short; because cavalry is best able to withdraw rapidly out of fire of the guns. But wherever we can use our artillery with effect, either by watching the opportunity, by advancing under cover, or by rapidity of movement, &c., our cavalry will have the best chances of victory in its subsequent attack.

3. In order that artillery may be at all times ready to open the introductory cannonade of the engagement, it is essential that it be

* Translated from General v. Hindersin's Memo., "Ueber den Gebrauch der Artillerie," by Captain F. C. H. Clarke, R.A.

not too far back in the order of march, and that at least one battery should follow in rear of the leading battalion.

In the event of the ground being much wooded, it would be desirable to march more battalions in front of the leading battery of artillery; but in open level country a strong body of artillery may advantageously follow in rear of the first battalion in the order of march.

4. Artillery should always bring its fire to bear upon that arm of the enemy which is the most formidable at the moment, and upon the annihilation of which the attainment of the immediate object of the engagement depends. It is obvious that if the enemy's artillery commands a defile which must be passed by our infantry or cavalry, our own guns must first engage those hostile guns. At the long ranges at which we have generally to open fire, nothing—even in open ground—will be seen of the enemy at the outset but his artillery; nevertheless, the old rule, repeatedly enjoined by Frederick the Great and Napoleon I., should not be overlooked—viz., whenever hostile battalions or bodies of cavalry present themselves as advantageous targets, our fire should be directed upon them.

Frederick the Great states his views on this subject as follows:—

"With regard to the first fault (that of directing the fire chiefly upon the hostile artillery) your whole attention and your entire fire must be alone directed with a view to making a gap in the lines of the enemy's infantry, causing disorder in his ranks, detaining his march, and preventing his movements from being carried out in an orderly manner. When this object has been attained, the infantry will be soon defeated, and the enemy's artillery will become silent of itself, and fall into your hands."

5. Cannonading at long distances, when the effect of the shot cannot be properly observed and no accurate correction made in the elevation, is a mere waste of ammunition. The judicious employment of ammunition is, however, one of the most important elements in gaining a victory; and many battles have been lost because ammunition has failed at the very moment when the enemy's complete defeat might have been prepared with the greatest chance of success.

Frederick the Great has written as follows on this subject:—

"This error of opening fire too soon is one which I have almost invariably remarked in our artillery. I know well that the impetuous bearing of infantry officers and of their nearest *pelotons* has often seduced artillery into the fault of endeavouring to insinuate itself alongside of the infantry; or perhaps to show their bravery, artillery officers continue firing until they remark that half their cartridges are expended, and for fear that the ammunition should be entirely exhausted, their fire diminishes when it should be heaviest."

It may here be of interest to quote the remark of many old artillery officers with regard to the great campaigns of 1813–15, that all distances immediately *on the enemy's front* appear shorter than in reality.

6. Firing should never be so rapid as to prejudice the *good* serving and laying of the piece—which are all-important—or to cause a want

of ammunition at important moments. The firing should be most rapid at close quarters, or when short favourable opportunities have to be taken advantage of—*e.g.*, when the enemy is passing a defile; when hostile artillery and infantry are replenishing their ammunition during the engagement; when there is any sign of consternation in the enemy's ranks, which might be converted into disorder; when the enemy's troops, from any cause, become massed; when they are caught in the act of deploying, or when they are relieving one another in the engagement, and so forth; and also when we have to give support to our own troops under similar circumstances.

An enemy who is merely cannonaded at long intervals, neither suffers severe loss, nor do the spirits of his men become depressed; he becomes, as it were, accustomed to the fire, and will not be sufficiently shaken for our infantry and cavalry to attack.

In point of fact, in the present day more ammunition may be expended in action whenever there is a railway in rear to facilitate its replacement; at the same time, we must not fire at too long ranges, nor fail to keep up proper connection with the first line of wagons by detaching men for that purpose.

It is the duty of field officers to regulate this matter, and notify the places where the ammunition columns are to be found during the battle.

II.—*On the Employment of Division Artillery.*

1. The proportion of artillery attached to Divisions of infantry is so regulated as to be equal to any circumstances which may occur in the engagement; a mere reinforcement from the reserve artillery—of the duties of which we shall presently speak—is seldom or never required.

2. The dissemination of Division artillery should be avoided; and the field officer who commands the Division artillery in each Division must take care that whenever circumstances do not require a distribution of the artillery on each flank, the whole of the Division artillery should be kept as much together as possible in one position. By that means the firing can be best controlled and regulated, and we are thereby enabled to produce an overwhelming effect at the right moment, and at the very point of the enemy's line of battle at which our infantry or cavalry is subsequently to be launched for a decisive attack.

In order to comprehend more clearly the circumstances under which the artillery may be distributed upon the flanks, we may give the following example:—A Division of infantry, hard pressed by a superior hostile force, has to fall back over a river defile (bridge); it sends the artillery forward to take up a position on the further bank, with the object of shielding the flanks of the retreating infantry from attack; if then the artillery be separated far enough to the right and left of the bridge, it may be so posted as to sweep the ground in rear of the retiring infantry of any hostile troops.

If a battery has to fight in detached portions, it should not be divided into half-batteries of three guns, but into divisions; placing

two divisions where the most guns are required, and the remaining division where less will suffice.

3. If an infantry brigade, &c., is detached for some special service in which the co-operation of artillery is necessary, the general commanding the Division will assign temporarily to this detachment such portion of the Division artillery as he may consider commensurate with the object to be accomplished, and the artillery so attached will return to its proper place in the Division on the completion of the service.

The same thing is done when advanced or rear guards have to be formed; under certain circumstances, these may also require horse artillery from the "reserve" in addition.

Light rifled batteries which combine rapidity of movement with effective fire at long ranges, are most adapted for advanced and rear guards. In the case of an advanced guard, they are well calculated to compel the enemy to an early deployment of his force, and to drive away his possibly well posted guns; in the case of a rear guard, they fulfil the important object of keeping the enemy at a respectful distance, and by pertinaciously remaining in a good position they can subsequently hasten after their own infantry (which has meanwhile withdrawn, under protection of the cavalry), and take up other rear-ward positions to shelter the retiring force.

4. That arm which at any given instant of an engagement becomes the chief arm, should always be allowed to select the ground most favourable for its position or for its advance. At all stages of the engagement at long ranges (2000 to 800 paces), artillery will be the chief arm, and should not be deprived by the other arms of the most favourable positions for its action: not only would it be disadvantageous for the artillery, but still more so for the infantry and cavalry, and indeed for the attainment of the whole object of the engagement.

If the chief *rôle* subsequently falls to the infantry or cavalry, then, *vice versâ*, the artillery should conform its movements, and take up positions from which it can afford those arms the greatest support in the engagement. If the artillery can remain in its position, so much the better, as it does not lose the time which would be occupied in limbering-up, moving forward, unlimbering, and afterwards finding the new range. An unbroken cannonade, and the continuous and effective support thereby afforded to infantry and cavalry in their attack, may contribute in no slight degree to paving the way to success.

5. It is an error for horse artillery attached to a cavalry Division to confine itself merely to driving after it, and waiting until some special duty is assigned to it by the commander of the Division. On the contrary, the field officer of the horse artillery—or, in his absence, the commander of the battery—must accompany the general of the Division in his reconnaissance of the enemy and the ground; as by this means alone can he find out the best positions for a well-timed employment of the horse artillery.

6. A rule has been laid down that rifled batteries should remain in position and continue firing at the long ranges (1400 to 2000 paces)

at which fire is first opened, whilst the infantry or cavalry with the 12-pr. S.B. batteries* advance to closer quarters with the enemy. This rule, however, is only valid if the enemy is posted on a ridge which is separated from the heights on which our own artillery was first posted by a valley, so that while our infantry, &c., is crossing the valley, the artillery can go on firing over its head; whereas if the latter also descended into the valley, this advantage would be lost. On more level ground, rifled batteries should also gradually advance, even to case shot ranges (600 paces); for if they continue in their original positions, they can, in the case of level ground, only fire through the intervals between the infantry, and must soon cease firing, which cannot fail to prove disadvantageous to the advancing infantry.

The only case when batteries can continue for a longer time in action at extreme ranges, and at the same time support the flanks of the advancing troops, is when they are posted on the outer flanks of the infantry; but even then they must eventually approach nearer to the enemy, so as to break him more effectually, and prepare the way more surely for the success of the infantry attack. Only under specially favourable circumstances, which are of rare occurrence, can artillery approach within 600 paces of hostile infantry, as the fire of the latter at these ranges is superior to that of the artillery; and only when the enemy's infantry is shattered, commences to waver, and shows signs of retreating, can we advance to within case shot range, and co-operate in deciding the defeat of the enemy—like Senarmont at Friedland, when he neutralised Ney's repulse, and enchained victory to the French colours.

7. When an infantry or cavalry Division deploys from column of route against the enemy, the deployment, if practicable and advantageous, should take place under cover of one or more batteries which are sent forward at a rapid pace to take up a position by which the deployment of the infantry is screened. The batteries must be cautious not to approach so near as to be liable to be captured. A Division would not bring all its guns into action at the outset, except under very urgent circumstances; as a general rule, only so many should be used as are necessary for the attainment of the object of the moment, the remainder being held in reserve—*i.e.*, in hand, ready to be used where wanted.

Especial attention may here be drawn to the fact that an infantry Division will often be able to cover this deployment with its infantry alone, by sending forward companies or whole battalions at the double to occupy beforehand any woods, buildings, &c., which are favourably situated for screening the deployment; whilst in the case of a cavalry Division, this protection for the deployment will have to be afforded in the majority of cases by its horse artillery, which must therefore be accompanied by a strong special escort.

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* The date of the issue of the instructions embodied in this Memo. is of a period anterior to the campaign against Austria and her allies in 1866. It will be remembered that the replacement of S.B. guns by rifled artillery had only partially taken place on the outbreak of hostilities.—Tr.

8. When a battery or Division (four batteries) of artillery is occupying a defensive position against the enemy, it should never quit it without express orders from superior authority. The last rounds fired into the closely packed advancing bodies of the enemy are the most effective; and even the loss of an entire battery, if necessary, will be more than compensated for by the great sacrifice of the enemy's men, and if taken advantage of by the commanders of the other arms, may lead to the luck being turned in our favour.

Artillery must not suppose that it can withdraw out of fire of every body of skirmishers which approaches within range of the battery; the main object of the engagement, which the general in command has in view, can alone decide the question. If a battery is menaced, or its position rendered untenable, by skirmishers who have crept up unperceived or are advancing upon it with a rush, it is the duty of the special escort and of the nearest battalions to drive away this body, small though it be, if prejudicial to the efficacy of the artillery fire.

The battery commander must also not forget the fact that he possesses the readiest means close at hand, in his case shot—a few rounds of which are sufficient to intimidate or drive away such an enemy; and although ammunition is generally too valuable to expend upon skirmishers, yet in the case in point it is not so, as we gain time to maintain our position and considerably diminish the loss of horses and men in the battery.

III.—*On the Employment of Reserve Artillery.*

Reserve artillery is chiefly used to appear rapidly and unexpectedly in superior force opposite some point of the enemy's line of battle, in order by its fire to prepare his defeat. It may also happen that the enemy, by reason of some vigorous measures or some piece of good fortune, is endeavouring to break through some point of our line of battle, or is commencing to give an unfavourable turn to the action by bringing a superior force to bear upon one of our wings; in such a case a rapid and vigorous employment of the reserve artillery presents an effective means of causing a turn in the luck and frustrating the enemy's plans.

In my opinion, those column formations, movements in column, deployments, &c., which find too much favour in peace time, cannot be employed even at long ranges from the enemy. The object is usually attained more quickly and with greater certainty by adopting the simplest formations, by coming into action rapidly, and by bringing up one battery after another; supposing it is not possible, or that it would be too troublesome a matter, to advance all the batteries simultaneously on a broad front into the position.

Horse artillery and light field batteries are best adapted for this rapid employment. The use of reserve artillery in detached portions to support the Division artillery is very subordinate, and should be avoided as much as possible, as by so doing the decisive functions of reserve artillery are weakened or annulled. Reserve artillery should not be brought into action at long ranges if it can be avoided; medium

and close ranges enable the fire to be more rapidly decisive and effective. With regard to the employment of reserve artillery and artillery generally (especially horse), it must never be forgotten that no arm is capable of bringing such rapid and important assistance as field artillery. To give an extreme example—which also includes minor ones—let us suppose the case of an army engaged in battle with the enemy, and that an army corps, a day's march or so distant, is on the march to its assistance. The infantry of this corps can obviously take no essential part in that day's battle, the horses of the cavalry will arrive too tired for an effective charge, but light field artillery—particularly horse artillery—can give efficient assistance; for directly the guns reach their position, the horses get time to take breath and rest while the guns are in action. For the same reason, no arm can take more rapid advantage of any fault committed by the enemy than light field artillery, as it can move as quickly as cavalry to the spot where it is wanted, and, having unlimbered, can throw its projectiles far more rapidly into the enemy's ranks. When large bodies of artillery are moving under fire, they are often compelled, both in advance and retreat, to cover their own movement. This is done by advancing or retiring in échelon. This formation is most necessary when a defile has to be crossed in presence of the enemy. The mode of carrying it out is perfectly known and much used.

IV.—*On the Employment of Artillery in Retreat.*

With regard to the conduct of artillery in retreat, it need be only specially remarked that on these occasions this arm, of all others, is more liable to be placed at a disadvantage. In retreat, Division artillery is only an accessory arm, and must consequently conform to the movements of the other troops, to give the latter something to fall back upon up to distances of 800 paces and more from the enemy, and to support them with its fire. Should further retreat become necessary, part of the Division artillery hastens onward to take up a supporting position, and at that point again gives security to the retreat; the remainder continues with the retiring troops, supporting them in their movements. If attacked by the enemy's cavalry—

(*a*) Horse artillery accompanying cavalry must seek out a position in rear from which it can best ensure the retreat of its own cavalry.

(*b*) Field artillery accompanying infantry must take up its position between the squares of the first line, and retire with them. If the troops in retreat reach a position which has to be held, the artillery must not mind the effect of the enemy's fire, but on the contrary must cling most pertinaciously to the other arms, firing calmly and resolutely to the very last.

Reserve artillery should be employed in retreat—

(*a*) To move to those points which are immediately threatened.

(*b*) To take up positions in rear at the right moment, for the purpose of securing the retreat of the Divisions, which must therefore retire upon those points.

In retreats, especially when the country is unknown, a mounted man should be sent on in front, to seek out passages over ditches, the best points of passage over swampy ground, &c., suitable roads through woods, &c., and generally to protect the battery from dangers to which artillery, more than any other arm, is exposed.*

When the order is received to abandon a good defensive position, it is most advantageous for the attacking side, and least advantageous for the defender, if the latter during the retreat fights his way continuously to the next good defensive position, and seeks to hold anew every small wood or height which may intervene.

It is different if a rear guard is ordered to fight to the last man in a disadvantageous position, with a view to obtaining a respite for the retreating main body. In this case it will be often advantageous for the artillery to retire in échelon, the outer échelons retiring first, and protecting the flanks of those which follow. Woods which are separated by an interval not exceeding the range of musketry should either be entirely left alone, or made use of with great caution.

The trophies of a victory are generally counted by the colours, standards, or guns captured, and it might appear from our observations on the courageous employment of artillery that the greater part of the guns might be liable to be captured by the enemy; but this is not so. The enemy only gets our guns if we meet with a defeat; but we suffer no defeat if the artillery is always employed with courage and intelligence, for in that case our cavalry and infantry will have the way to victory considerably facilitated.

If the enemy has forced his way into the battery, the artilleryman should be as jealous of abandoning his guns as the infantry soldier his colours, and should attack the foe with side-arms; whilst the infantry and cavalry will aid him in maintaining the guns, if those arms have seen, during the course of the fight, how earnest he has been, and what trouble he has taken to contribute to the victory.

BERLIN,
May 30, 1866.

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* When the establishment of horses permits, it is well for the battery commander, not only in retreat but on all occasions, to have an intelligent non-commissioned officer to send on duties of this nature.

PRINCIPLES

OF

CONSTRUCTION OF FIELD ARTILLERY CARRIAGES.

BY

CAPTAIN W. KEMMIS, R.A.

In considering the construction of field artillery carriages, it will be well first to review those principles which, more or less, must be carried out in the building of all in common, and then to make a few remarks upon the particular requirements which govern the details of construction of the various descriptions of carriages.

Essential Qualities.

The following qualities may be looked upon as the *desiderata* in a field artillery carriage—viz., "mobility," that the carriage may be brought rapidly, and without difficulty, into any required position, or change of position; "stability," that in any movement the carriage may be required to make, even if the ground is tolerably uneven, it may not overturn; "strength," "durability," and "simplicity" are essential qualities, which require no comment; and lastly, "convenience of transport" must of necessity be desirable in a country like Great Britain, with numerous large and distant colonies.

The first and chief point, then, to be kept in view in the construction of all field artillery carriages, is "mobility;" for without possessing this quality in a very high degree, they would be comparatively worthless.

In the following remarks, the question of the advisability of employing a two or four-wheeled carriage will not be entered into, it being assumed that the nature and purpose of the load compel the latter; which is, further, the best for draught, though the less advantageous for wheeling. Also, in all cases, the mode of draught will be taken as shaft draught, being that adopted in the service, as placing the carriage more under control in manœuvring than pole draught, and as being more advantageous for the wheel horses.

1. *Mobility.*—The "mobility" of a carriage is influenced by several things—viz., by the "traction" (commonly termed the "draught"), or amount of power requisite to put it in motion, and keep it in motion;

In retreats, especially when the country is unknown, a mounted man should be sent on in front, to seek out passages over ditches, the best points of passage over swampy ground, &c., suitable roads through woods, &c., and generally to protect the battery from dangers to which artillery, more than any other arm, is exposed.*

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BY

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Essential Qualities.

The following qualities may be looked upon as the *desiderata* in a field artillery carriage—viz., "mobility," that the carriage may be brought rapidly, and without difficulty, into any required position, or change of position; "stability," that in any movement the carriage may be required to make, even if the ground is tolerably uneven, it may not overturn; "strength," "durability," and "simplicity" are essential qualities, which require no comment; and lastly, "convenience of transport" must of necessity be desirable in a country like Great Britain, with numerous large and distant colonies.

The first and chief point, then, to be kept in view in the construction of all field artillery carriages, is "mobility;" for without possessing this quality in a very high degree, they would be comparatively worthless.

In the following remarks, the question of the advisability of employing a two or four-wheeled carriage will not be entered into, it being assumed that the nature and purpose of the load compel the latter; which is, further, the best for draught, though the less advantageous for wheeling. Also, in all cases, the mode of draught will be taken as shaft draught, being that adopted in the service, as placing the carriage more under control in manœuvring than pole draught, and as being more advantageous for the wheel horses.

1. *Mobility*.—The "mobility" of a carriage is influenced by several things—viz., by the "traction" (commonly termed the "draught"), or amount of power requisite to put it in motion, and keep it in motion;

by its capability of reversing; and by its power of passing obstacles. To render, therefore, a carriage mobile, "the draught must be as light as possible." This necessitates, in the first place, the load being a minimum—that is, the weight of the gun, or ammunition, &c., to be carried being given, the weight of the carriage a minimum—and in the second place, that the load be properly distributed over the axles.

Before passing on to the other points which affect the draught, it is to be noticed that the distribution of the load depends upon the relative diameters of the fore and hind wheels, and upon the fact that the traction of the fore carriage, taken by itself, is usually more difficult than that of the hind; because the fore wheels make, as it were, the tracks, and in so doing reduce the height of any obstacles for the hind. These considerations point to the reduction of the load upon the fore axle as compared with that on the hind; but, on the other hand, the fact must not be lost sight of, that if too much weight be thrown on the hind axle relatively to the fore, it will cause the hind wheels to sink too much in yielding ground, and thereby (though the decrease of weight on the fore axle tends, as before, to lighten it) to increase the draught on the whole.

Again, for lightness of draught, the axles must be of such length as to give the same track to both fore and hind wheels; in order that, as above, the fore may, in doing their own work, also assist the hind. The diameter of the wheels must also be a maximum, and that of the axletree a minimum. With regard to the former, the diameter of 5 ft. has been fixed upon as that most suitable for the field wheel.

Lastly, that the draught may be light, the point of the attachment of the traces must be the most favourable—that is, as regards height from the ground; it must be such as to give the most advantageous inclination to the traces. The point of attachment to the horse—viz., the collar—being fixed, experience has shown that this inclination should be about $6\frac{1}{2}°$.

The carriage, to be mobile, must, in addition to being light in draught, be "capable of wheeling, or reversing, very short;" that is, not only must the carriage be of a minimum length, but the angle through which the fore carriage can sweep must be as large as possible—which latter mainly depends upon the diameter of the fore wheels, and details of construction of the body of the carriage.

The mobility of the carriage is influenced by what may be called its "power of passing obstacles," which point, so far as the wheels and inclination of the traces are concerned, may be considered as included under "lightness of draught;" but beyond this, is influenced by the mode of connection of the fore and hind carriage, which should be such as to admit of vertical motion of the fore carriage about the point of connection, so that the fore carriage may move in that direction independent, to some extent, of the hind carriage. The distance between the axles also slightly affects the power of the carriage to pass obstacles, but need hardly be taken into account, as the length between the axles best suited for passing certain obstacles will not be the best for passing others. And here it may be as well to remark, with regard to the distance between the axles, that it does not in

ordinary cases affect the traction, providing that the relative position of the centre of gravity of the load as to the axles remains unaltered.

2. *Stability.*—"Mobility" in a field artillery carriage would not, so to speak, be perfect, unless accompanied by "stability," which point has, therefore, next to be considered. Stability is influenced by the number of points on which the carriage rests, and by the vertical and horizontal position of the centre of gravity with regard to those points. The carriage being supposed on the level, the first mentioned distance should be as small as possible, and the second as great as possible (which latter, with convenience of width, governs the track), to yield maximum stability. This will be readily understood by supposing a carriage placed upon the level, and a vertical drawn through the centre of gravity, then the carriage tilted over through a certain angle; when it will be seen that the higher the position of the centre of gravity, the greater the distance through which it has moved, and therefore the more nearly will the vertical then drawn through it be to falling outside the bearings on the ground. Again, with regard to the horizontal position of the centre of gravity from the bearing points, it is evident that the further it is from them, the greater moment the weight, acting at that centre, has to resist any force tending to overturn the carriage.

Stability in wheeling or reversing, will further be influenced (setting aside the weight of the carriage, already fixed at a minimum by the consideration of mobility) by the height and mode of connection of the fore and hind carriages, as well as by the height of the attachment of the traces to the fore carriage.

That the carriage may be stable in any position of rest or of motion to the front, it is simply necessary that the vertical through the centre of gravity should fall within the figure formed by joining with straight lines the points upon which it rests. In field artillery carriages, the stability is considered sufficient when the upsetting angle for the carriage, packed, is about 35°; that is to say, the vertical falls outside the points on which the wheels rest, and the carriage overturns, when it stands upon a side incline exceeding 35°.

3. *Strength and Durability.*—The next points to be taken into consideration in the building of the carriage, are "strength" and "durability." The material used should be the strongest consistent with lightness; the scantling of each particular part being, in the same view, at a minimum consistent with the stress which the part may be called upon to bear. The material should also be such as will stand well the effect of shot striking it, the action of climate, &c., and should not be liable to deteriorate when kept in store.

Of late years, wrought-iron has very much superseded wood as a material for carriages, being much more durable. For instance, a shot striking a bracket of an iron gun-carriage will make a clean hole through it, without splintering and damaging the adjacent parts; whereas a shot striking the bracket or trail of a wooden gun-carriage will splinter it, more or less. Notwithstanding, comparing iron with English oak, it is but slightly heavier for the same strength; because, from its nature, its mass can be better disposed to withstand any given

stress. Wrought-iron, however, is not so elastic as wood, and therefore will not absorb so much of any stress as the latter; and, again, has the defect of readily suffering deformation, and thus loss of strength through loss of form. This latter defect sometimes necessitates the scantling of the iron being made of greater dimensions than mere strength to resist a particular stress would require.

4. *Simplicity.*—"Simplicity" of construction in the carriage is the next quality to be kept in view; that is to say, as far as possible, there should be nothing complicated nor likely to get out of order; neither should any part be such that, if damaged, it could not readily be repaired. Again, looking at the carriages in the aggregate, the parts and fittings should, as far as possible, be interchangeable.

5. *Transport.*—"Convenience of transport" is a point which must not be lost sight of in building the carriage; in view of which, it should admit of being readily taken to pieces and conveniently stowed on board ship.

6. *Length.*—Lastly, the total length of the carriage should be at a minimum; not only, as mentioned before, for mobility, but that in column of route it may cover as little ground as possible.

A few further remarks may now be made upon the particular requirements of the gun-carriage, &c.

The Gun-Carriage, with Limber.

The present form of gun-carriage has been arrived at, as fulfilling the foregoing conditions, and also as convenient for bringing the gun into, and serving it when in, action; as furnishing a stable carriage for the gun in action; as allowing of a supply of ammunition and stores being carried with the gun, readily accessible for use; and as admitting of a proportion of men being carried upon the carriage in addition to its proper load.

With regard to the mobility of the gun-carriage, it is to be remarked that it has an advantage not possessed by ordinary carriages—viz., of having fore wheels of equal diameter to the hind, yet locking through a considerable angle. Further, the connection of the fore and hind carriage may be said to be perfect, as regards passing obstacles; for the vertical as well as the horizontal motion of the former is very independent of the latter.

In point of strength and durability, not only has the gun-carriage to be able to withstand the strains to which it may be exposed as a travelling carriage, but it also must have sufficient strength to withstand the action of the gun when fired at the most hurtful elevation.

In investigating the effect of the discharge of the gun upon the carriage, we may consider that discharge as simply producing a force or blow applied at the bottom of the bore, and acting in the line of the axis of the gun—though it is questionable whether the action is actually so simple. The gun—that is, its weight, charge, &c.—are supposed in the following remarks to be given and constant; and, unless the contrary

is specified, the carriage standing on the level, and the gun laid at any angle of elevation or depression. From the symmetry of the gun and carriage with regard to the vertical plane through their longitudinal axes,* we can further take the whole of the forces to be spoken of as acting in that plane. Taking, then, the single force applied at the bottom of the bore, we may conceive it resolved into two components—one horizontal, the other vertical. Now, a proportion only of this single force, or its components, is transmitted from the gun to the carriage; part—depending in amount upon the weight and thickness of metal of the gun—being expended upon the former.

Again, of the proportion transmitted to the carriage, the whole is not expended upon the carriage, but a small part transmitted to, and expended upon, the ground—the amount depending upon the nature of the latter. Now, the gun is supported upon, or attached to, the carriage at two points—viz., the trunnion holes, and the bearing of the elevating screw on the trail; but the attachment is not rigid, for the gun is moveable about the axis of its trunnions, and is hinged to the elevating screw, the latter being also moveable in a vertical plane round its bearing on the trail.

Taking, therefore, a certain horizontal and vertical force as transmitted from the gun to the carriage, we see, from the nature of the connection between the two latter, that the horizontal component will be applied at the trunnion holes, and the vertical component partly at the trunnion holes and partly at the bearing of the elevating screw—mainly, however, at the latter. The horizontal component decreases as the angle of elevation or depression with the horizontal at which the gun is fired increases. It exerts itself upon the carriage in two ways—viz., in giving it a motion of translation to the rear, and a twist or tendency to constrained motion about the point of the trail, as that point may be regarded for the instant as fixed. Hence, to render the effect of this component as little hurtful to the carriage as may be, the latter should in itself oppose the motion of translation as little as possible; which amounts to saying that its inertia, and consequently its weight, should be a minimum (the latter we have already seen mobility also demands); while to reduce the twisting strain to a minimum, the trunnion holes should be as low as other considerations will admit. The vertical component will act in an upward or downward direction, according as the gun is fired at an angle of depression or elevation with the horizontal, and will increase with the angle. If upward, it will tend to tear the carriage asunder; if downward, to crush it—the latter being that which tells most upon the carriage, on account of the resistance of the ground upon which the carriage bears. The body of the carriage is supported upon the ground at two points—viz., the axletree arms and the point of the trail; when, therefore, the blow of discharge is transmitted to the carriage, if the vertical component act downward, we shall have at these points certain resistances called into play, that at the arms being

* It is not only convenient, but necessary that these axes should lie in the same vertical plane, to prevent the carriage receiving a twist horizontally.

much greater than at the point of the trail; because the axis of the trunnion holes lies vertically to the front of the axis of the axletree, and also the bearing of the elevating screw is nearer the axletree than to the point of the trail—in fact, because the vertical component, part of which acts at the trunnion holes and part at the bearing of the elevating screw, acts as a whole at some point intermediate between the two.

Again, this being the position of the point of application, as it were, of the total vertical component, it is evident that the trail and brackets (as part of the trail) have to support the whole brunt of it, while the axletree has only to bear a part of that whole. If the vertical component act upwards, the resistances of the ground will not then be called into play, but the weight of the carriage acting downward at its centre of gravity will offer the resistance; the tendency being, as before said, to tear the carriage asunder. When the vertical component acts downwards, and the resistances of the ground are called into play, they will in general be less in total amount than the component itself, the excess of the latter being expended upon the ground. This excess will vary with the hardness of the ground, and the carriage will be saved according as the latter is more or less yielding. Just in the same manner, the ground, by its nature, will influence the recoil, and, as before mentioned, in so doing influence the amount of the horizontal component spent upon the carriage, and the portion transmitted to and expended upon the ground.

In a similar manner, the slope of the ground to the front or rear, by influencing the recoil, affects the destructive effect upon the carriage.

It only remains to be noticed, with regard to the force transmitted from the gun to the carriage, that in guns having the axis of the trunnions below the axis of the piece, other things equal, the blow upon the trail at the bearing of the elevating screw is more severe than in guns in which the axes intersect; because the impulse on the bottom of the bore, acting in the line of the axis, has a moment or twist round the axis of the trunnions.

Carriages having a detached elevating screw are liable to a second and destructive blow upon the trail, from the breech of the gun and the screw falling back to their place, after the rebound of the trail from the ground has thrown them up.

As regards serving the gun in action, it is to be observed that the carriage is admirably adapted for laying the gun; admitting of ready motion being given to the latter in a plane perpendicular to the axis of the trunnions and to the carriage itself, and therefore to the gun in a plane at right angles to the former.

As to furnishing a stable carriage for the gun in action, the form adopted gives three points of support, the vertical through the centre of gravity falling between them, and hence a stable carriage. Not only so, but a carriage that is stable when the gun is fired; as the axis of the gun lies in the vertical plane (the wheels being on the level) containing the centre of gravity of the system, while the rear point of support of the carriage is in the same plane, and at a sufficient distance from the centre of gravity.

It now remains to make a few remarks upon the parts of the gun-carriage in detail.

The wheels and axletree are of sufficient importance to be treated of by themselves, and it need only here be mentioned, with regard to the destructive action of the gun upon the carriage, and axletree in particular, that, looking at their inertia, the weight of the wheels should be a minimum (as well as for mobility).

The scantling of the parts has been arrived at from experience and experiment, as well as from scientific considerations; being always kept at a minimum consistent with proper strength, for the sake of mobility, which consideration in the following remarks is understood to be kept in view.

The wooden axletree bed, hitherto used, served as a convenient means of securing the axletree to the carriage body, more particularly in wooden gun-carriages; it also distributed the load in travelling, and the strain in firing, more uniformly over the axletree, serving by this means, and by its own additional strength, to admit of the axletree being made lighter than it otherwise could be.

In iron carriages, however, it gives no additional facility of construction, and though it has the advantage of assisting the axletree to some extent, it is a questionable advantage; so that in this case it would appear to be a superfluous, and it may even be said to be a faulty form of construction—a compound axletree, as it were, being made of two substances differing so much in elasticity as wood and iron, and further, the material having the greatest elasticity placed to receive the pressure or blow; in fact, the iron may be broken before the full strength of the wood has been called into play. For this reason, it is probable that in iron carriages of the future it will be dispensed with, and the axletree modified.

In form, the bed is of the same section throughout, but not rectangular; because while the upper surface is parallel to, and the sides perpendicular to, the under surfaces of the brackets into which it is housed, its under surface must be such as to be parallel to the ground when the trail is upon the limber-hook, in order that the lower surface of the axletree may be parallel to the same—that being the position of the axletree for which the lead and hollow are calculated.

The dimensions of the bed depend entirely upon the axletree; its length—in which direction the fibre should run—being the same as that of the body of the axletree; its depth being regulated by the height considered necessary to be given to the axis of the gun (which is governed by the general rule that the gun should be able to fire over a parapet 3 ft. 6 ins. high at 5° depression); and its width such that it may be able to retain a good hold upon the axletree without giving way itself.

The height of the brackets must be at a minimum consistent with the maximum elevation and depression necessary for the gun—viz., about 15° elevation, or 10° depression, being given when required—and also to give (in wooden gun-carriages) room for sufficient depth of housing over the axletree bed.

The depth must be kept, as stated, at a minimum, because the deeper the brackets, the stronger, and therefore heavier, they must be

in themselves; and again, because the higher they are, the less will be the stability of the system.

The thickness of the bracket should be at a minimum consistent with strength. Its length must be such as to afford secure attachment to the trail in wooden carriages; in iron carriages, the brackets and trail are in one.

With regard to the position of the trunnion holes in the brackets, it is ruled by the consideration that it must not be so far back as to make the weight on the limber hook—the position of which is, in a measure, fixed by other things—excessive, but such as easiness of lift in unlimbering demands; and, so far as it may be taken into account, of correct distribution of the load on the fore and hind axles. At the same time, the position of the trunnions must not be so far forward as that when the carriage is unlimbered and gun fired, the trail would rebound from the ground, and the system turn over to the front. Neither should the weight on the limber-hook be so little as in travelling over rough ground, or up an incline, to cause a succession of heavy blows by the trail against the key securing it. In practice, in gun-carriages for the lighter field guns, the axis of the trunnions—the gun being unlimbered and on the level—and the axis of the axletree of the carriage are very nearly in the same vertical plane; which with the construction of the trail, &c., causes the point of the trail to press upon the ground with a force equal to about half its own weight.

In the carriages for the heavier guns, it is found impossible to combine the required conditions in one set of trunnion holes, and it becomes necessary to have one set for the gun in travelling, and another in firing.

The dimensions of the trail are fixed as follows:—Its length chiefly depends upon the influence it has upon the recoil when the gun is fired, and therefore upon the extent to which it is considered desirable to check that recoil; bearing in mind, as before mentioned, that the more the recoil is checked, the greater will be the destructive effect upon the carriage. In this view, experience has shown that the angle which the trail makes with the ground should not exceed 22°. Setting this point aside, the length of the trail must be sufficient to prevent any danger of the gun and carriage turning over to the rear about its point on firing. Minor considerations which affect the length of the trail are, that it must be long enough to admit of easy access between the fore and hind wheels, and not so long as to make the fore and hind axles unnecessarily far apart. As we have seen, it is where the elevating screw is supported that the greatest breaking strain comes upon the trail, and where, therefore, its cross section must be the greatest; depending not only upon the amount of the blow communicated through the elevating screw—which is exceedingly difficult to calculate—but also upon the distance from the elevating screw to the point of the trail. Towards the point of the trail, though the cross section may be decreased with reference to the blow on the elevating screw, it must be such as to be able to withstand any lateral strain the trail may be liable to be exposed to; for instance, the jamming of the fore wheel against it in locking, and also any twisting strain in going over rough ground.

The limber is fitted to carry the supply of ammunition which accompanies the gun. Three points about it deserve notice—viz., its load, the position of the limber-hook, and the point of attachment of the traces.

The load on the fore axle, as before mentioned, should be less than that upon the hind axle; but the amount of difference on the gun-carriage must of necessity be more or less modified by the quantity of ammunition which is considered absolutely necessary to be carried with the gun.

The position of the centre of gravity of the load must always be such that the vertical through it will fall in front of the axletree, that there may be no tendency to rotation to the rear; otherwise, the position of the load must be such that when combined with the effect of the distribution of the remainder of the whole load, it will throw a sufficient amount of weight, and no more, upon the shaft horse's back. The ammunition being carried in boxes facilitates stowing on board ship, &c.

The height of the limber-hook from the ground is fixed by convenience of lifting the trail, for unlimbering and limbering-up; its position between the axles, by the length given to the trail, the proportion of the total load to be thrown upon each axletree, and, as far as possible, solidity of attachment to the body of the limber.

The considerations governing the point of attachment of the traces have been mentioned before, under the head of lightness of draught, in respect of mobility.

The Ammunition Wagon.

The wagon must be able to accompany the gun over any ground the latter may have to pass, therefore the general principles of mobility, &c., apply equally to it; and the present form of ammunition wagon has been arrived at as best carrying out these principles, and the particular purpose for which it is intended; the parts, so far as possible, being interchangeable with those of the gun-carriage.

With regard to the distribution of the load upon the axletrees, the arrangement of the ammunition in boxes admits of the approved proportion—viz. 1 : 2—being more conveniently and more nearly approached than in the gun-carriage.

Nothing requires to be said upon the parts of the wagon in detail. What has been said about the parts of the gun-carriage, viewing it as a travelling carriage, applies to it; the perch in the one, corresponding to the trail in the other.

The Remaining Artillery Carriages.

These carriages are not intended to come under fire in the same manner as the gun-carriage, or even as the ammunition wagon; yet, since they must always be within reach of the battery to which they belong, and therefore to some extent conform to its movements, the general principles of construction require to be carried out in them—at least such has been the view held hitherto, as is well expressed in

Migout and Bergery upon the theory of gun-carriages—viz., "that these wagons have not to follow all the movements of the troops, like the gun-carriages and ammunition wagons, nevertheless they require great mobility; for, having constantly to keep in the neighbourhood of the batteries, they take a part in the principal changes of position. It is even necessary, in certain cases, that they should be able to rejoin the other carriages, notwithstanding the difficulties of the ground. These considerations lead us to construct these wagons on the plan of the gun-carriage and ammunition wagon."

This view has, however, of late been modified—namely, in the substitution of a general service wagon for the old limber wagons, as simplifying the field equipment by reducing the number of different descriptions of wagons, and as being more convenient for transport of *matériel*.

The minor details of construction of the old limber wagons were governed entirely by the particular purpose for which each was intended. In all, the parts were, as far as possible, interchangeable; not only among themselves, but also, when practicable, with the parts of the gun-carriage and ammunition wagon, for the sake of simplicity of equipment.

As to the new general service wagon for the artillery, the principles of construction of that particular form of wagon belong more properly to the principles of construction of wagons for the transport service.

ROYAL ARSENAL,
July 1, 1873.

PRINCIPLES

OF

CONSTRUCTION OF TRANSPORT CARRIAGES.

BY

CAPTAIN W. KEMMIS, R.A.

Remarks.

What has been said in the preceding paper on the Construction of Field Artillery Carriages, viewing them as travelling carriages, is, in a modified form, applicable to transport carriages.

These carriages are not required, in general, to move over such broken ground as artillery carriages may have to surmount, nor to move at such rapid pace. Hence—and bearing in mind also their special purpose, namely, the conveyance of stores—we may regard their essential qualities as the following:—

Essential Qualities.

Capacity to receive, and strength to convey, their load.
Stability in carrying it.
Lightness of draught, and moderate mobility.
Durability, simplicity, and facility of shipment.

Before discussing these qualities in detail, it will simplify the subject to assume that the vehicles to be employed are wagons* (a few remarks upon carts being afterwards made); that the load to be conveyed, and team to draw it, are fixed; and also, for the time, to neglect the question of springs.

Capacity and Strength.

As to capacity for load—the first mentioned requisite—a wagon should be able to receive the weight it is designed to carry in a reasonably bulky form, without it being necessary to pack the load

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* Wagons not limbered; because it is undesirable to leave space between the axles of no use for loading, as in a limbered wagon.

very high—which is inconvenient, and otherwise objectionable. In point of strength, the wagon should, as regards the material of which it is constructed, and the scantling of the various parts, be able to support with safety its given load, and to take it without breaking down over a bad as well as a good road, or even across a small ditch, or other obstacle.

Now, the form of the fore carriage, and the manner of its connection with the hind carriage or body, influences to a very considerable degree the capability of the wagon to pass obstacles without hurt. For example: the fore carriage first meets any obstacle or rut to be passed, and in crossing it, rises and falls or falls and rises, while the hind carriage is still on the original level. This action necessarily throws a strain upon the connecting arrangement of the fore and hind carriages, as well as upon their surfaces of contact, to be repeated when the hind wheels arrive at the same obstacle. In most wagons, the connection between the fore and hind carriages is by a long vertical main pin; and the surfaces of contact, wheel plates or otherwise, are at some distance around or in front and rear of the point of connection. This being the case, it is evident that the strain in question will be less in proportion as the distance from the main pin or point of connection to the surface of contact is decreased, and also as the play of the pin is increased. (The strain upon the pin itself will, of course, increase with the amount of play allowed to the pin). Thus, the more nearly the bearing surfaces of the fore and hind carriages approach to unite in one point—as they do in a limbered wagon—and the more play there is at the point of connection—as in the description of wagon just named—the more strong will the wagon be for passing broken ground.

To reducing the bearing surfaces in an ordinary wagon—*i.e.*, one without limber—to one point, there are, however, objections; namely, that so doing decreases the stability, and under certain circumstances admits of the likelihood of the wagon body being much strained.

Stability.

The next essential quality in a wagon is stability; that is to say, a wagon should not overturn when tilted sideways through a considerable angle. As has just been stated, having the hind carriage bearing upon the fore carriage at only one point decreases the stability; because then the base formed by joining the bearing points of the body is a triangle outside of which the vertical through the centre of gravity will soon fall, supposing the carriage to be gradually tilted over; and of course, as soon as this happens, the wagon upsets.

We have, however, already seen that one bearing point between the fore and hind carriage makes a wagon much better adapted for going over rough ground. From this, and what has just been said about stability on three bearing points, it would appear that great stability, and at the same time perfect construction as regards strength, are incompatible, but that one quality must be more or less sacrificed to the other, unless the wagon be made of the form of a limbered wagon, similar to a field gun-carriage or gun ammunition wagon.

Mobility.

With regard to the third requisite in a wagon, the conditions which influence the draught have already been sufficiently dwelt upon when speaking of artillery carriages. The height of the hind wheel of transport wagons varies usually from 4 ft. 2 in. to 5 ft. The greater it is, the more advantageous for draught; but a high wheel carries with it the evil of increasing the height of the bottom of the wagon for loading, and diminishing the stability. The height of the fore wheel should be also as great as possible, for ease of draught. In most wagons, the height of the hind wheel being determined, that of the fore wheel is made a maximum consistent with locking under, so that the wagon may be able to reverse in a short space; in some wagons, however, the latter is sacrificed, and the fore wheel made of equal diameter to the hind.

Durability, &c.

The remaining essential qualities of a wagon need no comment.

Carts.

Carts are used for transport as supplementary to wagons; for they furnish convenient means of moving small loads. They could not entirely take the place of wagons, for their capacity is not sufficient; and even if made capacious enough, so many more carts than wagons would be required, that columns of route would be too long. Carts have, however, another and more serious defect—viz., that of being much more fatiguing to the shaft horse, not only from the amount of weight which must necessarily be thrown upon him, but from the jolts or shocks which, more or less, are communicated to him as the cart passes over rough ground. The position of the centre of gravity of the cart (and load) is the only point which needs particular notice in the construction. It should always lie to the front of the axis of the axletree, and only so far so as to throw a moderate weight upon the shaft horse. It might, at first sight, be supposed that it would be better to balance the cart exactly on its axletree, and not have any pressure upon the shaft horse when the cart is at rest. If, however, this was done, it would be found that the inequalities of even a tolerably good road would produce such jolts that the horse would be more fatigued than with a constant moderate pressure upon his back.

Springs.

The advantages obtained by the addition of springs to a wagon or cart, are "lightening of the draught," and "saving to the carriage and load in passing over rough ground." In order that a wagon or cart without springs may surmount each successive obstacle of a rough road, both it, and as a consequence its load, have to be raised to the height of the particular obstacle as the wheels pass it. Suppose, now, the same wagon

or cart to be fitted with springs. The body, with its load, will not have to be raised to the height of each obstacle; for, as the wheels surmount it, the springs will yield to some extent, consequent upon their pliancy and the *vis inertia* of the weight above them. In this manner it arrives that much less exertion is required to make a wagon with springs pass over an obstacle of given height, than to make the same wagon without springs pass it. In other words, the draught of the spring wagon is the easier. Springs have also the advantage of saving the wagon and its load. They do this by lessening the shocks due to the badness of the road, acting not only by reducing the height due to an obstacle through which the body must rise and fall, but also by rendering the blow less severe; in fact, they convert what would otherwise be a blow into a pressure.

On the fore carriage of a wagon, springs are particularly useful; as they allow of some yield when, by reason of the unevenness of the ground, extra pressure is thrown upon any part in particular of the bearing surfaces.

Two comparatively slight disadvantages accompany the use of springs. One is, that the body is not so perfectly rigid over its axles as if without springs—some slight lateral motion of the body and load above the axles being a necessary consequence of the nature of the connections; the other is, that the use of springs necessitates the bottom of the wagon being rather higher than it otherwise need be. Both these points affect the stability, and the latter also convenience of loading.

It may also be urged that the addition of springs renders the construction of a cart or wagon more complicated and delicate. No doubt, to some extent, this is the case; but the springs used in the service—viz., the semi-elliptical—are simple in construction and easily repaired.

Springs on a wagon or cart should be of such strength that, with the full load and the wagon at rest, they should not yield more than half the distance (measured along the radius of the spring at the centre, or over the point of attachment) through which they would have to bend to become straight.

The strength of a steel spring is proportional to the number of leaves and to the width and thickness of each leaf, while it is inversely proportional to the span. Founded, no doubt, upon this, and upon the results of experiments, the following formulæ, which give very good approximations to the truth, were given in the "Engineer" of January 12, 1872:—

Let s = span or length in inches of a spring,
b = breadth in inches of a leaf,
t = thickness in sixteenths of an inch of a leaf,
n = number of leaves,
c = a constant,

then, the working strength of the spring in tons $= \dfrac{b \times t^2 \times n}{s \times c}$, where $c = 11{\cdot}3$; and the elasticity or deflection per ton of load $= \dfrac{s^3 \times c}{b \times t^3 \times n}$, where $c = {\cdot}105$.

In the transport heavy spring wagon (made by contract), which has second class wheels and axles and takes a load of 2 tons, in a hind spring we have

$$s = 43\tfrac{1}{2}''$$
$$b = 2\tfrac{1}{4}''$$
$$t = \tfrac{1}{4}''$$
$$n = 10$$

Therefore the working strength of the spring $= \dfrac{\frac{9''}{4} \times (4)^2 \times 10}{43\frac{1}{2}'' \times 11{\cdot}3}$ $= {\cdot}73$ ton, or $\frac{219}{300}$ ton; while, supposing the distribution of the load over the axles to be in the proportion of 1 on the fore axle to 2 on the hind, the actual load upon the spring $= \frac{1}{2}$ of $1\frac{1}{3}$ tons $= \frac{2}{3}$ ton, or $\frac{200}{300}$ ton.

Also, for the same spring, the deflection per ton of load $= \dfrac{\left(\frac{87}{2}\right)^3 \times {\cdot}105}{\frac{9}{4} \times (4)^3 \times 10}$ $= 6''{\cdot}002$; or for the actual load of $\frac{2}{3}$ ton upon the spring $= \frac{2}{3} \times 6{\cdot}002$ $= 4''{\cdot}001$, which exceeds by $0''{\cdot}626$ half the amount of deflection required to bring the spring straight—which latter, as already mentioned, ought not to be exceeded.

NOTES ON ARTILLERY TACTICS.

BY

LT.-COL. W. J. WILLIAMS, C.B., R.A.

Attack.

1. The fire of artillery from a "distance" would not inflict much loss upon an enemy awaiting our attack.

Villages, detached buildings, walls, and even entrenchments might be more or less ruined by our fire from a distance; but except in the case of setting a place in flames and making it untenable, we should have almost wasted much ammunition. The power of the defence would be very little impaired. The enemy would not let his men remain in any place we cannonaded: he would mark his front, in the open, only by guns at full interval and infantry in extended order: the intended defenders of places in his line, his supports, and all his real strength, would be retired out of the zone of our fire. From a distance, we could not sufficiently well note the movements within his lines which the enemy would make to withdraw his people from our fire. A well directed fire of shell or shrapnel takes effect upon only a narrow belt of ground. Except where his guns stood in action, or where a few infantry might lie in extended order, the enemy would take care to avoid the dangerous ground with all his people.

2. It would be advisable to commence a battle with a cannonade at a moderate range.

The front of an enemy in position would always be marked, at least, by guns placed in first line to fire upon us as soon as we should come within range. It would be well to engage at once an artillery duel with those guns of the enemy, and at the same time to cannonade any places in his line. Our principal object in this cannonade and artillery combat, would be to occupy the attention of the enemy along his line, whilst we should reconnoitre the field of battle and form our plan of attack, and our infantry should be coming up into hand from the rear. Although the harm which we might do to the enemy, by burning or ruining his places, weakening his artillery, and firing upon any infantry or cavalry who offered us a target, would not be our principal object in this preliminary cannonade, our guns ought to be advanced to within a moderate range, that we might not expend much ammunition without

obtaining some material results. Regarding only the due economy of ammunition, we ought not to fire upon the guns of the enemy at a greater range than 1700 yds. Considering, on the other hand, that guns once placed in action ought not to be retired; and that our object here would not be quickly to obtain decisive results which could only be gained at a great sacrifice, we must be careful not to approach too near. It would seem to follow that our guns ought to come into action at ranges of from 1500 to 1700 yds.

3. It would be necessary to cover an infantry attack by artillery at a short range.

The infantry fire of the defence would be superior to the infantry fire of the attack. The infantry and artillery fire of the defence would be so superior to the infantry fire of the front of the attack, that the infantry, advancing in the tactical formation best suited to their enterprise and to the nature of the ground, would be shot down until they were disorganised, disheartened, and defeated, if the covering fire of artillery did not effectually aid them. The infantry could be effectually aided only by artillery at a short range: Our guns must be placed so near to the enemy as to have an easy command of the ground over which he must advance his supports and reserves; and so near, as to be able to fire across the flank and front of our infantry until a late moment of the attack. The nearer our guns were to the enemy, the more effectually we could search his position, and the longer could we continue to fire across the front of our attack. On the other hand, we must beware of making our guns a useless sacrifice. Having regard to these opposing considerations, it would seem that guns, to cover an infantry attack, ought to advance to within from 1000 to 800 yds. of the enemy.

Artillery thus advanced would always suffer severely; but this would be the only way to use artillery decisively in aid of an infantry attack. The loss to the guns would not be so great as may, perhaps, be imagined. The guns must not rashly be sent out to where they might fall into an ambuscade. They could, generally, soon after their arrival in position, be protected by infantry skirmishers in front of their outer flanks; and their advance ought to be so timed that they would not be in action for ten minutes before the enemy had to deal with our infantry approaching to close quarters.

4. The best combination of the two arms would be when infantry attacked on a front of one battalion, and artillery, on both flanks, covered the infantry at a range of from 800 to 1000 yds.

Taking the front of the infantry attack at 400 paces, guns placed 400 paces wide of the infantry and 1000 yds. from the enemy, could fire across the flanks and front of the infantry, so as to strike the enemy in his front at a point opposite to the centre of the attack, until the head of the attack was within about 300 yds. of the enemy; and the guns could continue to fire across the flanks of our infantry, so as to strike the front of the enemy opposite to the flanks of our attack, and the supports and reserves of the enemy opposite to the centre of the attack, until our infantry were within charging distance.

There could be nothing better than this, unless the enemy should suffer our guns to take up a position whence they could enfilade him.

5. There could be no proper combination of the two arms if the infantry were to attack on a greater front than the front of two battalions.

If the infantry attack were made on a front of three battalions, or of 1200 paces, guns placed 600 paces wide on a flank, and at a distance of 1000 yds. measured perpendicularly to the front of the enemy, would be firing at a range of 1400 yds. upon the front of the enemy opposite to the centre of the attack; and the guns could not continue to fire upon the front of the enemy opposite to the centre of the attack after the head of the attack had come to within 500 yds. of the enemy. The guns could not be placed so as to cover the advance of our infantry to close quarters.

Defence.

6. The divisional artillery ought, for the most part, to be placed in front, in line with the foremost infantry, on the ground intended to be defended.

Guns ought to be placed in front, that they may fire upon the enemy as soon as he comes within range, and that they may never be prevented from crossing their fires in front of the defence. The use of guns in a line attacked by infantry is to prevent the enemy from forming his supports and reserves in column. If we had no guns in front, the enemy would advance his supports and reserves in columns. Columns, preceded by a thick firing line, would be his safest formation under musketry fire; and the pressure and rush of his columns would be hard to beat in the assault.

Guns ought generally to be distributed along the front of a position in the proportion of one battery to two battalions. There might be favourable points where it would be advantageous to place more than one battery; and there might be more than the length of two battalions of front, where it would be useless to place guns.

7. Guns placed in front of a position ought not to be retired in face of an infantry attack.

The guns ought not to be retired, because they most clearly mark the line of the defence; because their withdrawal must unsteady and discourage our infantry at a critical moment; and because they would be wanted in front. The guns must be served to the last.

The teams might be unhooked and retired. Infantry could lie between the guns, and close up in their rear, to protect them. The attack of the enemy would make for the infantry between the batteries, and not for the batteries themselves.

Shorncliffe,

May 22, 1873.

ON THE

INFLUENCE OF THE WIND ON THE FLIGHT OF PROJECTILES.

BY

MAJOR E. MAITLAND, R.A.

Since the introduction of rifled guns has enabled us to shoot with considerable accuracy, it has become a matter of importance to eliminate, as far as possible, the causes of incorrectness of either range or line in artillery practice. One of the chief of these causes is the force of the wind; and an endeavour is made in this paper to supply the means of making the requisite corrections, so that we may be able to foretell how much our range will be increased or diminished by the wind, and what allowance to the right or left should be made in the direction of the projectile.

The correction for range was a very difficult matter to deal with before the publication of Professor Bashforth's valuable tables; and, owing to the varying ratio of resistance to velocity, when the latter was high, could not be made with the desired accuracy. The lateral correction appears to be a simple mathematical problem, and may, perhaps, be already worked out elsewhere; though I am not aware that it is so.

For practical purposes, it may be considered that wind is simply air moving horizontally with a measurable velocity, which we will call W. It is assumed to move uniformly in a straight line; that is, to retain its direction and velocity during the flight of the projectile. We may correct the practice for range and accuracy, even if the wind be gusty, provided that the force, direction, and duration of the gusts be observed.

Assuming, then, that the wind is blowing with a uniform horizontal velocity W, in a direction making an angle D with the direction of the line of sight of the gun, we have to determine its effect on—

(1) The range.
(2) The line.

Resolving the velocity of the wind parallel and perpendicular to the line of sight, we have for the portion which affects the range,

$$W \cos D \cos E;^*$$

and for the portion which affects the line,

$$W \sin D.$$

Since the wind is assumed to move horizontally, it will not affect the height above the earth's surface to which the projectile will rise; and therefore the time of flight will remain practically unaffected thereby.

Supposing the shot to start with a velocity V, and the resolved part of the wind's velocity, $W \cos D \cos E$, to be in the same direction in which the projectile is travelling, then the latter will evidently encounter the resistance of the air due to the difference between the two velocities; that is,

$$V - W \cos D \cos E.$$

Should the resolved part of the wind's velocity, $W \cos D \cos E$, be blowing in the direction opposite to that in which the projectile is moving, then the latter will meet with the resistance due to the sum of the two velocities; that is,

$$V + W \cos D \cos E.$$

That part of our problem which concerns the range, may now be thus stated:—

$$\text{Given} \begin{cases} W = \text{velocity of wind in feet per second,} \\ D = \text{angle between direction of wind and line of sight,} \\ V = \text{muzzle velocity of projectile in feet per second,} \\ d = \text{diameter of do. in inches,} \\ w = \text{weight of do. in pounds,} \\ t = \text{time of flight in seconds,} \\ E = \text{angle of elevation of gun.} \end{cases}$$

To find the range.

First, let the resolved part of the wind's velocity be *with* the projectile.

Taking Professor Bashforth's work on the "Motion of Projectiles," we turn (for ogival-headed shot) to Table IX., and there look out the number of seconds placed against the velocity equal to $V - W \cos D \cos E$. Multiplying the given time t (if not known, it can readily be calculated from other tables in the same book) by $\frac{d^2}{w}$, we add the product to the time found in Table IX.; opposite the sum of these times we find the velocity remaining when the projectile arrives at the mark. Turning now to Table VIII., we find given the distance passed over between the muzzle velocity ($V - W \cos D \cos E$) and the final velocity as just found in Table IX. Calling this distance S, we then divide S by $\frac{d^2}{w}$, and we have the distance through the air that would be travelled

---

* E being the angle of elevation.

by a shot of the given proportions in the direction of the axis of the gun, starting with a velocity equal to $V - W \cos D \cos E$ during a time t.

But since the tables are calculated for horizontal ranges, we must multiply our result by the cosine of the angle of elevation, which gives us

$$S \cos E \frac{w}{d^2};$$

and this is the true horizontal range *through the air*.

But the air is in motion, and therefore to find the true horizontal range over the earth's surface we must add the distance travelled by the air during the flight of the shot. This will give

$$S \cos E \frac{w}{d^2} + Wt \cos D;$$

which is the required range under the given conditions.

If the wind be acting against the projectile, we must start with

$$V + W \cos D \cos E,$$

and must subtract $Wt \cos D$ from $S \cos E \frac{w}{d^2}$.

For the sake of example, I give a table constructed from some practice with the 40-pr. R.M.L. gun. The estimate of the wind's force is made by the officer conducting the practice, and is therefore liable to error. To register the force and direction of the wind with accuracy, it would be necessary to place an anemometer near the range, and to observe it during the actual flight of the shot.

Table taken from Practice with 40-*pr. R.M.L. Gun at Shoeburyness. Sights, vertical; rifling,* 1 *turn in* 35 *cals.; diameter of projectile,* 4·67″; *length,* 13·52″; *capacity,* 3·187 *lbs.; weight empty,* 35·312 *lbs.; brand of powder, R.L.G.* 1629.

Date.	Nature and weight of projectile.	No. of rounds.	Charge.	Elevation, (corrected).	Observed range.	Time of flight.	Calculated muzzle veloc.	Wind.	Observed deflection right.	Remarks.
			lbs.	° ′	yds.	secs.	f.s.		yds.	
22. 3. 72	Common shell, plugged and weighted to 38·5 lbs.	10	7	5 3	2317	6·8	1274	See remark.	4·5	Wind light, and all round compass; average about *nil*.
"		4	"	10 2	3890	12·6	"	1	15·0	
5. 4. 72		6	"	"	3769	12·4	"	80° 3	34·8	Wind probably a little more than 3.
8. 4. 72		10	"	2 6	1200	3·2	"	32° 4	1·6	Wind probably a little less than 4.

The first thing we have to do is to calculate our muzzle velocity, which will be the same (or very nearly so) in each case, since the charge and brand of powder are the same. We have, in the first case, a series of observations, comprising ten rounds, where the effect of the wind is practically *nil*, and therefore we will select this case to give us the muzzle velocity.

$$\log \frac{d^2}{w} = 9\cdot7531,$$

$$t\,\frac{d^2}{w} = 3\cdot851 \text{ secs. (reduced time)},$$

$$\text{range} \times \text{secant } 5^\circ\ 3' \times \frac{d^2}{w} = 3952 \text{ ft. (reduced range)}.$$

Let us try 1300 f.s. first for the velocity. Opposite 1300 in Table IX. is 1·258 secs.

$$1\cdot258 + 3\cdot851 = 5\cdot109.$$

Opposite 5·109 we find 896·6 as the remaining velocity.

Turning to Table VIII., opposite 1300 we have 1865.

$$1865 + 3952 = 5817.$$

Opposite 5817 we find 899·1 as the remaining velocity. Thus our velocity has diminished more rapidly in the time travelled than in the space travelled. This shows that we have taken our velocity too high.

Let us try 1274 as the muzzle velocity. Proceeding as before, we shall find that each table gives 891·6 as the final velocity; which shows 1274 to be correct.

This method of approximation comes out much more readily, after a little practice, than would be at first supposed, and is, I believe, exceedingly accurate.*

Sir Henry James, R.E., in his work on meteorology, gives the following notation for the velocity of the wind:—

			f.s.
1 =	7·071	miles per hour	= 10·37
2 =	14·142	"	= 20·74
3 =	21·213	"	= 31·11
4 =	28·284	"	= 41·48, &c., &c.,

and this notation is, I believe, used at Shoeburyness.

Employing these data to correct the other observations in the table of practice, with regard to the wind, we have in the second series, comprising four rounds, a wind directly in favour of the projectile.

$$\therefore \cos D = 1,$$

$$W \cos E = 10\cdot21 \text{ f.s.},$$

$$V - W \cos E = 1263\cdot79.$$

* I hope that Professor Bashforth will pardon me for thus using his tables. My apology must be that I have found them very useful in this manner, as well as in the determination of the effect of the wind on the range.

Opposite 1263·79, in Table IX., we have

$$\begin{array}{rr} & 1{\cdot}419, \\ \text{but } t\dfrac{d^2}{w} = & 7{\cdot}137, \\ \hline \text{giving} & 8{\cdot}556, \end{array}$$

opposite which we find 769·75 as remaining velocity.

Turning to Table VIII., we have

$$\begin{array}{lrlr} \text{opposite} & 1263{\cdot}79 & \text{the value} & 2069, \\ \quad " & 769{\cdot}75 & \quad " & 8719, \\ \hline \end{array}$$

$$\text{and } S = \text{the difference} = 6650 \text{ ft.}$$

$$\therefore\ S \cos E \frac{w}{d^2} = \overset{\text{ft.}}{11561},$$

$$Wt = \quad 130{\cdot}7,$$

$$\overline{\quad 11691{\cdot}7 \text{ ft.}}$$

Therefore the true range will be 3897·2 yds. It is, in fact, as observed, 3890 yds.

For the third series, comprising six rounds, we have

$$W \cos D \cos E = \overset{\text{f.s.}}{15{\cdot}32},$$

$$\therefore\ V + W \cos D \cos E = 1289{\cdot}32\,;$$

because the direction of the wind is opposed to that of the projectile.

Proceeding as before, we arrive at 776·6 as the final velocity, which will give

$$S \cos E \frac{w}{d^2} = \overset{\text{ft.}}{11510}$$

$$\text{less } W \cos Dt = \quad 193$$

$$\overline{\quad 11317 \text{ ft.}}$$

Therefore the true range will be 3772 yds., and it is observed as 3769 yds.

If there were no wind, a reference to the tables will show us that the range of the 40-pr., under the above conditions (except as to wind), would be 3842 yds.; so that the correction applied for the wind will in the second series be 55 yds., and in the third 73 yds.

In the fourth series, comprising ten rounds, fired at an elevation of 2° 6′, the wind, as estimated, gives a range of 1211 yds., the observed range being 1200.

These results are very close, when it is considered how rough a method is employed for the registration of the wind. In the fourth series the wind was probably less than 4, and in the third it appears likely (from the large deviation) that the wind was more than 3.

We have now to consider the effect of the force of the wind on the line of flight, and to calculate the deviation from this cause.

Let p = pressure of wind in pounds per square foot,
A = area of longitudinal section of shot in square feet;

then pA will represent the pressure of wind on side of shot tending to turn it out of the original line of flight.

If the shot were perfectly smooth, the effect of the wind on its side would be $\frac{2}{3}pA$; but since the surface of the projectile is rough, both at the sides and at the base, and as it is, moreover, furnished with numerous studs, I have estimated that the pressure will be fairly represented by pA; and from the calculation of many practice tables I believe this to be practically accurate.

Sir Henry James, R.E., gives the following ratio of pressure to velocity of wind:—

$$p = \cdot 005 V^2 \text{ in miles per hour;}$$
$$\text{or } p = \cdot 00232438 V^2 \text{ in f.s.}$$

Now, if we regard the wind as a constant force blowing across the range, and acting uniformly on the projectile, we shall have a curve resembling a parabola as the path of the latter; and for heavy shot and short ranges, or light winds, this method would give tolerably accurate results, and would only require the simple formula

$$S = t^2 p \sin D \frac{Ag}{2w}$$
$$= \text{deviation in ft.}$$

This equation is not accurate enough for light shot and high winds, since the wind communicates a certain amount of sideways or crab-like velocity to the projectile, and would ultimately cause it to travel as fast across the range as the wind itself is travelling.

It is clear, then, that the pressure of the wind on the side of the shot is that due to the difference between the sideways velocity of the latter, and the velocity across the range of the former.

Putting v as the sideways velocity of the projectile, communicated to it by the wind, we have

$$W \sin D - v$$

as the difference between velocities of wind and shot across the range; and thus, to find the pressure, we have

$$p = \cdot 00232438 \, (W \sin D - v)^2.$$

Putting f as the force of the wind acting on the side of the projectile, we have

$$f : g :: pA : w;$$
$$\therefore f = \frac{pAg}{w}$$
$$= \frac{\cdot 00232438 Ag}{w} (W \sin D - v)^2$$
$$= a \, (W \sin D - v)^2;$$

where a is a constant for each nature of projectile.

We have, then,

$$f = \frac{dv}{dt} = a\,(W \sin D - v)^2;$$

$$\therefore \frac{dt}{dv} = \frac{1}{a} \cdot \frac{1}{(W \sin D - v)^2}.$$

Integrating,

$$t = \frac{1}{a} \cdot \frac{1}{W \sin D - v} + C.$$

But it is clear that

when $t = o$ then $v = o$,

$$\therefore\ C = -\frac{1}{aW \sin D};$$

$$\therefore\ t = \frac{1}{a} \cdot \frac{1}{W \sin D - v} - \frac{1}{aW \sin D}.$$

Disentangling v, we have

$$v = W \sin D - \frac{W \sin D}{atW \sin D + 1} = \frac{ds}{dt}.$$

Integrating, we obtain

$$S = W \sin Dt - \frac{1}{a} \log_e (atW \sin D + 1) + C';$$

and when $t = o$ then $S = o$,

and $\therefore\ C' = o$;

and thus, substituting its value for a, we have

$$\text{Deviation in ft.} = W \sin Dt - \frac{w}{\cdot 00232438 Ag} \log_e \left(\frac{\cdot 00232438 AgW \sin Dt}{w} + 1 \right).$$

In this formula, the first term of the right hand side of the equation gives the amount of distance travelled by the wind across the range at any given time t from the starting of the projectile; and the second term gives the amount of space lagged behind by the shot at that time; the difference being, of course, the actual sideways travel of the shot.

In the third series given in the table of practice, taking the wind at 3, as estimated, the formula would give the deviation due to this cause as 12·8 yds., reducing the observed deflection to 22 yds., against 15 in the second series. It appears probable, as before mentioned, that the wind was really rather more than 3.

I append a second table, showing the results obtained by applying this formula to the correction of practice for accuracy. The wind was evidently observed with great care by the officer conducting the practice, and its frequent shifts are, no doubt, faithfully registered. An inspection of the table clearly indicates, however, that to record accurately the force and direction of the wind during the actual flight of the shot, an efficient instrument is absolutely necessary.

Table taken from Practice with 64-pr. R.M.L. converted Gun at Shoeburyness, for trial of wood Tangent Scale inclined at 2° 16′ to the vertical. Diameter of Projectile, 6·22″; length, 16″; weight, 64·5 lbs. 14. 8. 73.

No. of round.	Time of flight.	Observed deflection left.	Wind.	Deflection due to wind.	Corrected deflection.	Means.	Remarks.
	secs.	yds.					
1	14·2	8·6		0	8·6		
2	13·8	8·0	3 to 4	0	8·0		The elevation was 12°, and the range 4300 yds.; muzzle velocity not known.
3	14·1	11·0		0	11·0	10·2	
4	13·6	12·4		0	12·4		
5	14·1	11·0	—	0	11·0		
6	13·8	1·0	3 to 4	6·1	7·1		
7	14·0	5·0	16°	6·1	11·1		
8	13·9	6·4		6·1	12·5	11·4	
9	13·8	9·0	—	6·1	15·1		
10	13·9	0	4	0	0	0	This round is evidently exceptional.
Mean = 13·92					Mean = 10·75		
11	9·7	1·4	3 to 4	3·6	5·0		
12	9·1	0	20°	3·6	3·6		The elevation was 8°, and the range 3076yds.; muzzle velocity not known.
13	9·2	4·6		3·6	8·2	6·0	
14	9·4	5·0		3·6	8·6		
15	9·4	1·0	—	3·6	4·6		
16	9·5	7·0		0	7·0		
17	9·5	5·0	4	0	5·0		
18	9·5	4·6		0	4·6	6·7	
19	9·4	7·0		0	7·0		
20	9·5	10·0		0	10·0		
Mean = 9·42					Mean = 6·35		

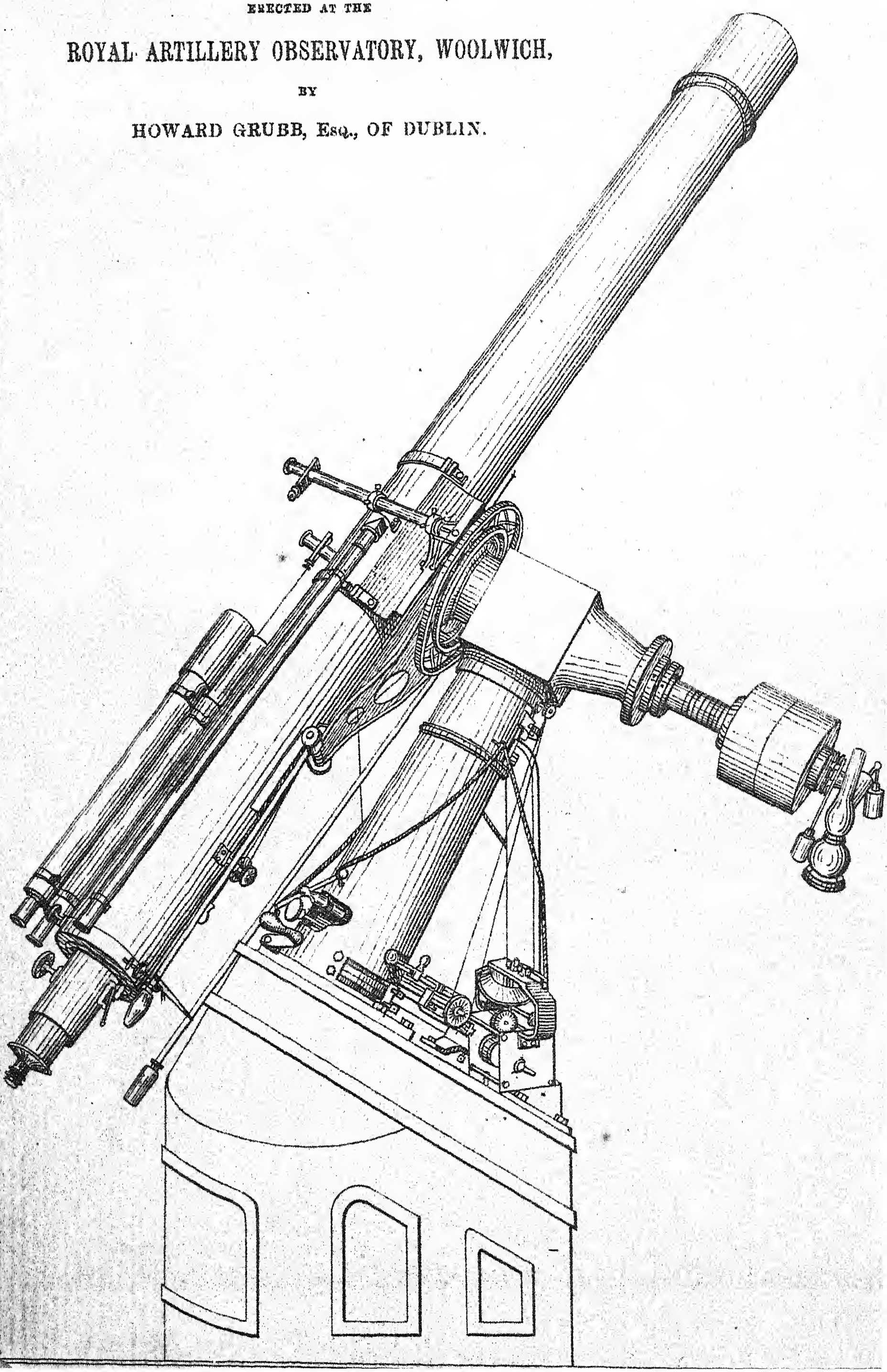
EQUATORIAL TELESCOPE

ERECTED AT THE

ROYAL ARTILLERY OBSERVATORY, WOOLWICH,

BY

HOWARD GRUBB, Esq., OF DUBLIN.



REPORT OF TELESCOPE SUB-COMMITTEE,

AND A

SHORT DESCRIPTION OF THE INSTRUMENT

(By the Maker, H. GRUBB, Esq., of Dublin).

At the general meeting of the members, Royal Artillery Institution, on the 23rd May, 1871, it was proposed by the Committee, and unanimously agreed to by the meeting—

"That a refracting telescope of 7-in. aperture, equatorially mounted, be procured for the Observatory of the Institution, at a cost of about £500."

The Committee, at its next meeting, on the 29th May, 1873, nominated a Sub-Committee to take the necessary measures for giving effect to the above resolution, consisting of—

PRESIDENT.

Col. (now Major-Gen.) W. J. Smythe, R.A., F.R.S.

MEMBERS.

Major Haig.	Capt. C. O. Browne.
Capt. Ford.	Lieut. (now Capt.) Sladen.

Capt. Burnaby, *Secretary*.

The vacancies on the Sub-Committee afterwards occasioned by the retirement of Capt. Burnaby and the lamented death of Major Haig, were supplied by the appointment of Capt. W. H. King-Harman as Secretary, and Capt. F. Duncan, M.A., &c.

The Sub-Committee at once placed itself in communication with the makers of large telescopes, and also sought the advice of gentlemen actively engaged in the use of such instruments. One of the members was enabled, through the obliging kindness of Dr. Huggins, to examine the 15-in. refractor lately constructed for the Royal Society, and entrusted for special investigation to his care.

After careful consideration, the Sub-Committee decided to commit the construction of the telescope to Mr. H. Grubb, of Dublin, who had given so much satisfaction in the case of the instrument just named, and of others.

A detailed agreement was accordingly drawn out with him, in the preparation of which the Sub-Committee was most ably assisted by Warren De La Rue, Esq., V.P.R.S., who further permitted them to insert a clause providing that no part of the price of the telescope was to be paid until the instrument was examined and passed by him.

The telescope was to have been finished by the end of August, 1872, but various causes prevented its being actually mounted in its place in the Observatory until the end of December in that year.

One of the causes of delay is noteworthy, as it appears not to have been encountered before—viz., variation in the performance of the object-glass, caused by variations of temperature, and traceable to the constitution of the material. The process of re-annealling the glass having been tried without effect, a new glass had to be obtained from the makers—Messrs. Chance, of Birmingham.

As in July, 1872, the telescope was all finished with the exception of the object-glass, permission was given to Mr. Grubb to bring it over from Dublin, and proceed with its erection. It was then discovered that the base upon which the pier of the telescope was to rest, was in contact with the floor of the equatorial room, and was also unsafe. The old stones forming the upper surface of the base were taken away, and a fine block of granite—obtained from the Dockyard by the courtesy of the Royal Engineer Department—was laid in their place. The work, which demanded much skill and patience for its execution, was admirably performed by a squad of gunners, under the immediate direction of Major Betty, R.A.

The new object-glass being finished, and all other preparations being completed, the telescope was put together in its place in the last days of November, 1872, by Mr. Grubb; but the weather continued for many weeks most unfavourable for observations.

On the 4th of February, 1873, Mr. De La Rue was able to give the instrument a preliminary examination. He pronounced most favourably on its construction generally, but noted some small mechanical defects which it would be desirable to rectify before testing its optical qualities. His remarks were communicated to Mr. Grubb, by whom they have been acted on, and the telescope may be said to be now quite complete. There now only remains to test the object-glass.

The state of the weather, and Mr. De La Rue's indisposition, have prevented hitherto any real judgment on this point. Pending its determination, which the Sub-Committee is sanguine will prove highly satisfactory, and in recognition of the ingenuity and skill evinced by Mr. Grubb in the construction of the instrument, the Secretary was authorised to pay him, on account, £250.

In now handing over the telescope to the Committee, R.A. Institution, the Sub-Committee begs to express its sense of the forbearance of the members at the delay in the accomplishment of its task. To the interruptions inseparable from the construction of an instrument so accurate and complicated, have been added the special causes of delay stated above. The Sub-Committee, while it has never ceased to urge on the progress of the work, has kept in mind, as of primary importance, the excellence of the instrument.

In conclusion, the Sub-Committee would venture to suggest that this valuable instrument should, together with the rest of the Observatory, be placed under the charge of a small Sub-Committee, composed of officers conversant with the use of instruments; and that a competent person—N.C. officer or civilian—be placed in direct charge of the instrument, the necessary sanction to be obtained for his residence in the building, and the removal of the two Institution orderlies.

W. H. KING-HARMAN,
Capt. R.A.,
Secretary.

WOOLWICH,
May 5, 1873.

The general form of the 7-in. equatorial recently erected for the Royal Artillery Institution, Woolwich, is the same as that of the 15-in. equatorial erected for the Royal Society at Dr. Huggins' Observatory (Tulse Hill, S.W.), and the 15-in. and 12-in. equatorials now in course of construction by the same maker for the Lord Lindsay and the University of Oxford respectively. It has the advantage of combining great steadiness with circumpolar motion from horizon to zenith.

The *objective* is 7 ins. aperture; but as the components are cemented, the light transmitted is about equal to a $7\frac{5}{8}$ uncemented objective. The focus is about 9 ft.

The *telescope* is supplied with two finders of $2\frac{1}{2}$ ins. aperture; bifilar micrometer; transparent position circle, and arrangements for dark and bright field illumination of micrometer wires, as described in the following paper, which was read before British Association, 1872, by Mr. Howard Grubb; also convenient arrangements for final balancing of tube, &c. :—

"The rack and pinion tube carrying the eye-piece or micrometer revolves freely in the casting which forms the lower end of the telescope tube, and carries a brass plate (all cast in one piece), on which is cemented a flat ring of plate glass, muffed on back, and in front varnished with an opaque varnish. Through this varnish the divisions are cut, so that on being illuminated from behind, the divisions appear bright upon a black ground. The vernier is similarly treated, and the whole of this circle being covered with a cap, with a glazed window only sufficiently large to expose the vernier and about 15° of the circle, is protected from possible injury and is read most conveniently through this window, being illuminated by a beam of light constantly directed upon it from a lamp hanging on end of the declination axis, as will be afterwards explained.

"Between the fixed casting which forms the end of the telescope tube and that which revolves in it is another metallic circle cut into 360 teeth on edge, and with 90 holes drilled accurately on face: into the teeth on edge is geared a screw which is mounted on fixed casting, one revolution of which is of course equal to an angular movement of 1°.

"In the other (outer) moveable brass circle is mounted a steel pin working up and down in a small cylinder; this pin, being pressed down by a small spiral spring, enters into one or other of the 90 holes in the intermediate circle, and thus clamps the whole eye-end to the intermediate circle, in which condition a slow motion is obtained by the endless screw. When it is desired to move the eye-end through

characters of the illumination are under complete control of the observer while actually observing.

"One other matter is perhaps worthy of note.

"The want of a convenient method of mapping nebulæ or faint stars by a reticulated diaphragm of bright lines in the field of view has long been felt, and the various methods of using diamond scratches on glass or illuminated lines are subject to objection, and troublesome to manage. A simple method of using an image of such a diaphragm instead of the actual diaphragm itself, here suggests itself.

"Referring to the portion of the rays used for bright field illumination, and shown in Fig. 1, suppose the small diagonal mirror, R', to be replaced by an equally small prism having such a convex power that it forms an image of any object at the end of the declination axis exactly in the same plane as the image formed by the objective; then any kind of reticulated diaphragm of bright lines on dark ground can be placed on the end of the declination axis which would have a suitably prepared carrier for them, and their image would be seen in the field of the telescope of any colour and any intensity desired."

The *right ascension circles* are 8 ins. diameter, divided on palladium alloy to 2 minutes of time; the lower circle fixed to polar axis, and read by opposite verniers to 2 seconds (time), and the upper (adjustable, and carried by clock) read for sidereal time by opposite fixed verniers, and differentially for actual right ascensions by eight verniers on lower circle.

The *declination circle* is 15 ins. diameter, divided on 12-caret gold to 10′ of arc, and read—

(*a*) By rough setting reader from eye-end,
(*b*) By opposite micrometer microscopes, subdividing divisions of arc to single seconds.

The *illumination* is altogether supplied by one lamp, hanging on end of declination axis by a universal joint.

This one lamp supplies illumination to the declination circle in three places, position circle in one, and the reflectors for illuminating the wires of micrometer in both dark and bright field illuminations.

The *clockwork* is regulated by the most approved form of governor, and is supplied with means of altering its rate without stopping, also lunar wheels, to change motion of telescope instantaneously from sidereal to mean lunar. The clock drives telescope by a square-threaded screw ground into a sector of long radius, and cut most accurately according to the method of cutting teeth of sector of great Melbourne telescope (described in "Philosophical Transactions" by Rev. Dr. Robinson, F.R.S., and T. Grubb, F.R.S.)

The *framework of mounting* is altogether of cast-iron to within 3 ft. of floor level; the framing being made in three parts, and having convenient arrangements for adjustment in latitude and meridian.

The following nine operations are accessible to an observer while actually observing:—

1 & 2. Clamping and slow motion in right ascension. The clamping by cords; the slow motion by either of three methods—

(*a*) Hook's joint handle from right ascension slow motion screw, which connects right ascension sector and clamp.

(*b*) By a button at eye-end of telescope, from which the motion is carried by a system of bands to a pulley on same right ascension slow motion screw.

(*c*) Or by an endless cord from a pulley on clock shaft, which acts on a pair of differential wheels, producing a slight acceleration or retardation of clock's rate.

[N.B.—Inasmuch as this last apparatus constitutes, while not in actual use, a simple coupling to the clock shafts, it is not open to the objections to the ordinary means of producing this acceleration or retardation, when the motion is carried through several additional wheels and pinions.]

3 & 4. *Clamping and slow motion in declination.* The clamping by Hook's joint handle; the slow motion by Hook's joint handle, from a screw ground into a toothed sector of 18 ins. radius on declination clamp.

5. *Reading declination circle*, sufficiently for finding purposes, by a long micro-telescope with right-angle prism on end.

6 & 7. Arrangements for bringing into use the dark or bright field illuminations of micrometer as required.

8 & 9. The regulation of both the intensity and the color of the illumination.

The illumination arrangements, eye-end, and transparent position circle, method of working right ascension slow motion by bands, and accelerating and retarding mechanism, are all peculiar to the instrument, and applied for the first time.

THE MOBILITY OF FIELD ARTILLERY;

PAST AND PRESENT.

BY CAPTAIN HIME, R.A., F.S.S.

[CONCLUSION.]

THE time is come when it is not alone fitting, but necessary to bring to a close the series of papers on the mobility of field artillery.

In the first place, the principal object for which these papers were begun—the introduction of gun-axletree seats in the field batteries—has long since been accomplished.

Secondly, I am prevented by circumstances from carrying out my original intention of finishing the series by a comparison of the English field artillery with the chief European field artilleries, founded upon personal observation.

Thirdly, since the publication of the "History of the Royal Artillery," by Captain F. Duncan, R.A., it would be labour lost to dwell upon the importance of mobility as an attribute of field artillery. In every page of that comprehensive and valuable history may be found proofs, far clearer and more convincing than any I could bring forward, that the progress of the English field artillery has been quite as much due to the development of its mobility as to the development of its fire.

I began my papers with the aphorism of General Foy:—"Le premier mérite de l'artillerie, après la bravoure des canoniers et la justesse du tir, c'est la mobilité." I end them with the equally important maxim of Sir Augustus Frazer:—"The strength of field artillery is not to be estimated by the number of guns, but by their efficiency of movement, and by the skill of the men who work them."

ALDERSHOT,
Nov. 1873.

ADDENDA AND CORRIGENDA.

Vol. VI., p. 433, line 1 from top—*for* "bravourie," *read* "bravoure."
" p. 439, line 11 from top—*for* "bravourie," *read* "bravoure."
Vol. VII., p. 133, line 7 from top—*for* "it," *read* "the lesson."
" p. 138, line 12 from top—*for* "had undertaken," *read* "undertook."
" " line 24 from top—*dele* "had."
" p. 456, line 1 from bottom—*after* "1871," *insert* "Vol. I."
" p. 465, line 16 from bottom—*after* "1871," *insert* "Vol. I."
" p. 466, line 2 from top of the "Remarks" in the table—*for* "guns," *read* "6-prs."
Vol. VIII., p. 281, line 1 from bottom—*for* "Organum," *read* "Organon."
" p. 290, line 21 from top—*for* "Anglaises," *read* "Anglais."

ON THE

PRESSURE REQUIRED TO GIVE ROTATION TO RIFLED PROJECTILES.

BY

CAPTAIN NOBLE, F.R.S., &c.

(*Late R.A.*)

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1. In a paper published in Vol. III. of these "Proceedings," (p. 409), I gave some investigations on the ratio between the forces tending to produce translation and rotation in the bores of rifled guns.

2. My object in these investigations was to show—1st, that in the rifled guns with which experiments were then being made, the force required to give rotation was generally only a small fraction of that required to give translation; 2ndly, that in all cases (and this was a point about which much discussion had taken place), the increment of gaseous pressure (that is, the increase of bursting force) due to rifling was quite insignificant.

3. In the paper referred to, although the formulæ were sufficiently general to embrace the various systems of rifling then under consideration in England, they did not include the case of an increasing twist, which has since been adopted for the 8-in. and all larger guns of the British service; neither was our knowledge of the pressure of fired gunpowder sufficient to enable me to place absolute values on either of the forces I was considering.

4. Since the date at which I wrote, an extensive series of experiments has been made in this country; and the results of these experiments enable me to give with very considerable accuracy both the pressure acting on the base of the projectile and the velocity at any point of the bore. I am therefore now able not only to assign absolute values where in my former paper I only gave ratios, but also to show the amount by which the studs of the projectiles of heavy guns have been relieved by the introduction of the accelerating twist known as the parabolic system of rifling.

5. Very little consideration will satisfy anyone conversant with the subject, that in the ordinary uniform spiral or twist the pressure on the studs or other driving-surface is a maximum when the pressure on the

base of the shot is a maximum, and becomes greatly reduced during the passage of the shot from its seat to the muzzle of the gun. In my former paper I showed, in fact, that in a uniform twist the pressure on the studs was a constant fraction of the pressure on the base of the shot, the value of the fraction of course depending on the angle of the rifling; and as it is evident that the tension of the powder-gases at the muzzle is very small when compared with the tension of the same gases at the seat of the shot, it follows that in such a system of rifling the studs may have scarcely any work to do at the muzzle, while they may be severely strained at the commencement of motion.

6. If, then, the defect of the ordinary or uniform system of rifling be that the studs are severely strained at the first instants of motion and are insignificantly strained at the instant of quitting the gun, it is obvious that it is possible to remove this inequality, and at the same time allow the projectile to leave the bore with the same angular velocity, by reducing the twist at the seat of the shot, and gradually increasing it until it gains the desired angle at the muzzle. In fact, if we know the law according to which the pressure of the powder varies throughout the bore, it is theoretically possible to devise a system of rifling which shall give a uniform pressure on the studs throughout the bore.

7. These reasons doubtless led the late Ordnance Select Committee, to whom the application of the increasing twist to the service guns is due, to propose its introduction; and they selected as the simplest form of an increasing spiral the curve which, when developed on a plane surface, should have the increments of the angle of rifling uniform. This curve is, as is well known, a parabola; and as considerable advantages have been claimed for the parabolic system of rifling, I propose in this paper to examine and evaluate them.

I may add that I should not have given the results I now give, before the full experiments made by the Committee of Explosives, as well as some investigations undertaken by Mr. Abel and myself are published, were it not that several groundless assertions concerning the Woolwich rifling have recently appeared, and have led to much discussion and very unnecessary uneasiness.

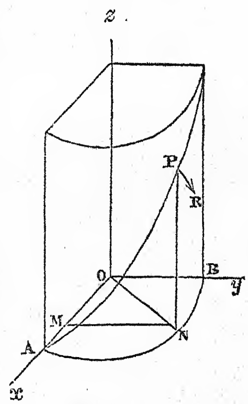
8. The argument commonly advanced against an accelerating twist is based upon the fact of the shot moving slowest at first, it being supposed that while moving slowest the shot will require less force to make it rotate; but there is a fallacy in this argument, which lies in confounding velocity with rate of acceleration. The shot undoubtedly moves slowest at first, but it acquires velocity most rapidly at first, and it is the *gain* of velocity that determines the strain upon the stud.

9. The first question, then, which I propose is, to determine the pressure on the studs of a projectile fired from a gun rifled on a parabolic or uniformly increasing twist; and in this investigation I shall adopt the notation used in my former paper.

10. Take, then, as the plane of xy a plane at right angles to the axis of the gun. If the angle of rifling commence at zero, increasing to, say one turn in n calibres, let the plane of xy pass through the commencement of the rifling; but if the rifling do not commence at zero,

it will be found more convenient to make the plane of xy pass through the point where the twist would be zero were the grooves sufficiently prolonged. Let the axis of x pass through one of the grooves; and, for the sake of simplicity, we shall suppose the rifling to be given by one groove only. Let the axis of z be coincident with that of the gun; let AP (see Fig. 1) be the groove or curve described by the point P, and let P (x, y, z) be the point at which the resultant of all the pressures tending to produce rotation may be assumed to act at a given instant. Let the angle $AON = \phi$.

Fig. 1.



11. Now, the projectile in its passage through the bore is acted on by the following forces:—

1st. The gaseous pressure G, the resultant of which acts along the axis of z.

2nd. The pressure tending to produce rotation. Calling this pressure R, and observing that it will be exerted normally to the surface of the groove, we have for the resolved parts of this pressure along the co-ordinate axes, $R \cos \lambda$, $R \cos \mu$, and $R \cos \nu$—λ, μ, and ν being the angles which the normal makes with the co-ordinate axes.

3rd. The friction between the stud or rib of the projectile and the driving-surface of the groove. This force tends to retard the motion of the projectile; its direction will be along the tangent to the curve which the point P describes. If μ_1 be the co-efficient of friction, and if α, β, γ be the angles which the tangent makes with the co-ordinate axes, the resolved portions of this force are $\mu_1 R \, . \cos \alpha$, $\mu_1 R \, . \cos \beta$, $\mu_1 R \, . \cos \gamma$.

12. Summing up these forces, the forces which act

$$\left.\begin{array}{l} \text{parallel to } x \text{ are } X = R \, . \, \{\cos \lambda - \mu_1 \cos \alpha\}, \\ \quad ,, \quad y \;\; ,, \;\; Y = R \, . \, \{\cos \mu - \mu_1 \cos \beta\}, \\ \quad ,, \quad z \;\; ,, \;\; Z = G + R \, . \, \{\cos \nu - \mu_1 \cos \gamma\}; \end{array}\right\} \dots\dots\dots\dots (1)$$

and the equations of motion are

$$M \, . \, \frac{d^2 z}{dt^2} = G + R \, \{\cos \nu - \mu_1 \cos \gamma\}, \quad \dots\dots\dots\dots (2)$$

$$M \, . \, \frac{d^2 \phi}{dt^2} = \frac{Yx - Xy}{\rho^2}, \quad \dots\dots\dots\dots (3)$$

ρ being the radius of gyration. Equations (1), (2), and (3) are identical with those I formerly gave.

13. Now, in the case of a uniformly increasing twist, the equations to the curve which when developed on a plane surface is a parabola, may be put under the form

$$x = r \cos \phi; \;\; y = r \sin \phi; \;\; z^2 = kr\phi. \dots\dots\dots\dots (4)$$

Hence

$$dx = - r \sin \phi \, . \, d\phi; \;\; dy = r \cos \phi \, . \, d\phi;$$

$$dz = \frac{kr}{2z} \, . \, d\phi; \;\; ds = \frac{r}{2z} \sqrt{4z^2 + k^2};$$

and we have, to determine the angles which the tangent to the curve described by P makes with the co-ordinate axes, the equations

$$\left.\begin{aligned} \cos\alpha &= \frac{dx}{ds} = \frac{-2z \,.\, \sin\phi}{\sqrt{4z^2+k^2}}, \\ \cos\beta &= \frac{dy}{ds} = \frac{2z \,.\, \cos\phi}{\sqrt{4z^2+k^2}}, \\ \cos\gamma &= \frac{dz}{ds} = \frac{k}{\sqrt{4z^2+k^2}}. \end{aligned}\right\} \quad \ldots\ldots\ldots\ldots\ldots\ldots(5)$$

14. In the Woolwich guns the driving-surface of the groove may be taken, without sensible error, as the simpler form of surface where the normal to the driving-surface is perpendicular to the radius, the surface itself being generated by that radius of the bore which, passing perpendicularly through the axis of z, meets the curve described by the point P; but in the first instance I shall examine the more general case, where the normal makes any assigned angle with the radius.

Assume, then, that on the plane of xy the normal makes an angle δ with the radius of the gun. The driving-surface of the groove is then swept out by a straight line which, always remaining parallel to the plane of xy, intersects the curve described by P, and touches the right cylinder whose axis is coincident with that of z, and whose radius $= r \,.\, \cos\delta$.

Now, the equations to the director being given by (4), and that to the cylinder, which the generator always touches, being

$$x^2 + y^2 = (r\cos\delta)^2, \quad \ldots\ldots\ldots\ldots\ldots\ldots(6)$$

it is easily shown that the co-ordinates x_1, y_1 of the point of contact of the tangent to the cylinder drawn from P parallel to the plane xy, are

$$\left.\begin{aligned} x_1 &= r \,.\, \cos\delta \,.\, \cos(\phi-\delta), \\ y_1 &= r \,.\, \cos\delta \,.\, \sin(\phi-\delta), \end{aligned}\right\} \quad \ldots\ldots\ldots\ldots\ldots\ldots(7)$$

and that the equation to the driving-surface is

$$x \,.\, \cos\left\{\frac{z^2}{kr} - \delta\right\} + y \,.\, \sin\left\{\frac{z^2}{kr} - \delta\right\} = r \,.\, \cos\delta. \quad \ldots\ldots\ldots\ldots(8)$$

15. The angles which the normal to this surface makes with the co-ordinate axes are given by

$$\cos\lambda = \frac{\left(\frac{dF}{dx}\right)}{\sqrt{\left(\frac{dF}{dx}\right)^2 + \left(\frac{dF}{dy}\right)^2 + \left(\frac{dF}{dz}\right)^2}},$$

with similar expressions for $\cos\mu$ and $\cos\nu$. But

$$\left(\frac{dF}{dx}\right) = \cos\left(\frac{z^2}{kr} - \delta\right); \quad \left(\frac{dF}{dy}\right) = \sin\left(\frac{z^2}{kr} - \delta\right); \quad \left(\frac{dF}{dz}\right) = \frac{2z}{k} \,.\, \sin\delta;$$

$$\sqrt{\left(\frac{dF}{dx}\right)^2 + \left(\frac{dF}{dy}\right)^2 + \left(\frac{dF}{dz}\right)^2} = \frac{1}{k}\sqrt{4z^2(\sin\delta)^2 + k^2}.$$

Therefore the angles which the normal to the driving-surface makes with the axes are given by

$$\left.\begin{aligned}\cos\lambda &= -\frac{k\,.\cos\left(\frac{z^2}{kr}-\delta\right)}{\sqrt{4z^2(\sin\delta)^2+k^2}},\\ \cos\mu &= -\frac{k\,.\sin\left(\frac{z^2}{kr}-\delta\right)}{\sqrt{4z^2(\sin\delta)^2+k^2}},\\ \cos\nu &= -\frac{2z\,.\sin\delta}{\sqrt{4z^2(\sin\delta)^2+k^2}}.\end{aligned}\right\}\quad\ldots\ldots\ldots\ldots\ldots(9)$$

16. Substituting in (2) and (3) the values given for $\alpha, \beta, \gamma, \lambda, \mu, \nu$ in (5) and (9), the equations of motion become

$$M\,.\frac{d^2z}{dt^2} = G - R\left\{\frac{2z\sin\delta}{\sqrt{4z^2(\sin\delta)^2+k^2}}+\frac{\mu_1 k}{\sqrt{4z^2+k^2}}\right\},\ \ldots\ldots(10)$$

$$M\,.\frac{d^2\phi}{dt^2} = \frac{R\,.\,r}{\rho^2}\left\{\frac{k\,.\sin\delta}{\sqrt{4z^2(\sin\delta)^2+k^2}}-\frac{2\mu_1 z}{\sqrt{4z^2+k^2}}\right\};\ \ldots\ldots(11)$$

and from (11),

$$R = \frac{M\,.\,\rho^2}{r\left\{\frac{k\,.\sin\delta}{\sqrt{4z^2(\sin\delta)^2+k^2}}-\frac{2\mu_1 z}{\sqrt{4z^2+k^2}}\right\}}\cdot\frac{d^2\phi}{dt^2}\cdot\ \ldots\ldots(12)$$

17. To determine $\frac{d^2\phi}{dt^2}\cdot$

From (4),

$$kr\phi = z^2,$$

$$\therefore\ kr\,.\frac{d\phi}{dt} = 2z\,.\frac{dz}{dt},$$

$$kr\,.\frac{d^2\phi}{dt^2} = 2\,.\left\{z\,.\frac{d^2z}{dt^2}+\left(\frac{dz}{dt}\right)^2\right\};$$

$$\therefore\ \frac{d^2\phi}{dt^2} = \frac{2}{kr}\cdot\left\{z\,.\frac{d^2z}{dt^2}+v^2\right\};\ \ldots\ldots\ldots\ldots(13)$$

and substituting this value of $\frac{d^2\phi}{dt^2}$ in (12),

$$R = \frac{2M\rho^2}{kr^2\left\{\frac{k\,.\sin\delta}{\sqrt{4z^2(\sin\delta)^2+k^2}}-\frac{2\mu_1 z}{\sqrt{4z^2+k^2}}\right\}}\cdot\left\{z\,.\frac{d^2z}{dt^2}+v^2\right\},$$

or, for brevity,

$$= A\left\{z\,.\frac{d^2z}{dt^2}+v^2\right\},$$

or, substituting the value of $\frac{d^2z}{dt^2}$ derived from (10),

$$= A\left\{\frac{G\,.\,z}{M}-\frac{Rz}{M}\left(\frac{2z\,.\sin\delta}{\sqrt{4z^2(\sin\delta)^2+k^2}}+\frac{\mu_1 k}{\sqrt{4z^2+k^2}}\right)+v^2\right\};$$

and from this expression may be deduced

$$R = \frac{2\rho^2 \{Gz + Mv^2\}}{\frac{(k^2r^2 + 4\rho^2z^2)\sin\delta}{\sqrt{4z^2(\sin\delta)^2 + k^2}} + \frac{2\mu_1 kz(\rho^2 - r^2)}{\sqrt{4z^2 + k^2}}} \ldots\ldots\ldots\ldots\ldots\ldots(14)$$

18. Equation (14) gives the pressure acting between the studs or rib of the projectile and the driving-surface of the groove at any point of the bore, and for any inclination of the driving-surface; but, as before stated, in the Woolwich guns the normal to the driving-surface (that is, the line of action of R) may, without material error, be considered as perpendicular to the radius.

If in (14) δ be put $= 90^\circ$, the equation is simplified; and the resulting expression gives the total pressure on the studs for the Woolwich guns.

Putting, then $\delta = 90^\circ$, (14) becomes

$$R = \frac{2\rho^2\sqrt{4z^2 + k^2}\,(Gz + Mv^2)}{kr^2(k - 2\mu_1 z) + 2\rho^2 z(2z + \mu_1 k)} \ldots\ldots\ldots\ldots\ldots\ldots(15)$$

19. Compare now (14) and (15), the equations giving the pressure on the studs for parabolic rifling, with the equations subsisting where a uniform twist is used.

For a uniform twist, we have, as I formerly showed,

$$R = \frac{2\pi\rho^2}{\frac{\mu_1(2\pi\rho^2 k - rh)}{\sqrt{1 + k^2}} + \frac{(2\pi\rho^2 + rhk)\sin\delta}{\sqrt{k^2 + (\sin\delta)^2}}} \cdot G, \ldots\ldots\ldots\ldots(16)$$

where h is the pitch of the rifling, k the tangent of the angle which the groove makes with the plane of xy, the other constants bearing the meaning I have already assigned to them in this investigation.

20. In the Woolwich guns, where $\delta = 90^\circ$, (16) becomes

$$R = \frac{2\pi\rho^2\sqrt{1 + k^2}}{hr(k - \mu_1) + 2\pi\rho^2(\mu_1 k + 1)} \cdot G, \ldots\ldots\ldots\ldots\ldots\ldots(17)$$

21. I proceed to apply these formulæ, and propose to examine what are the pressures actually required to give rotation to a 400-lb. projectile, fired from a 10-in. gun with battering charges, under the following conditions:—1st. If the gun be rifled with an increasing twist, as at present. 2nd. If it be rifled with a uniform pitch; the projectile in both cases being supposed to have the same angular velocity on quitting the gun. As the calculations for the uniform pitch are the simpler, I shall take this case first.

22. I have before remarked that with a uniform twist the pressure on the studs of the projectile is a constant fraction of that on the base of the shot, and represents, so to speak, on a reduced scale, the pressure existing at any point in the bore of the gun. Calling the fraction in equation (17) C, we have

$$R = C \cdot G, \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(18)$$

where

$$C = \frac{2\pi\rho^2\sqrt{1 + k^2}}{hr(k - \mu_1) + 2\pi\rho^2(\mu_1 k + 1)} = \cdot 04426, \ldots\ldots\ldots\ldots(19)$$

the values of the constants in (19) being in the case of the 10-in. gun as follows:—

$$\rho = \cdot 312 \text{ ft.}, \; k = 12\cdot 732, \; h = 33\cdot 333 \text{ ft.}, \; r = \cdot 417 \text{ ft.}, \; \mu_1 = \cdot 167.$$

Hence

$$R = \cdot 04426 \,.\, G. \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(20)$$

23. But the values of G are known with very considerable exactness from the investigations of the Explosive Committee under the presidency of Colonel Younghusband. The following table gives the value of G (that is, the total pressure in tons acting on the base of the projectile) for a charge of 70 lbs. of pebble powder at various points of the bore, and the corresponding values of R. It will be remarked how high the pressure on the studs is when that on the base of the shot is a maximum, and how rapidly the strain decreases as the shot approaches the muzzle.

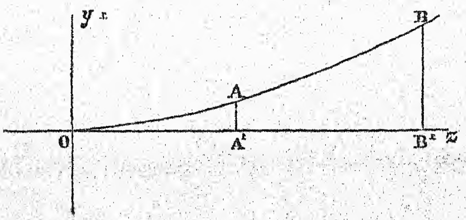
Table showing the pressure on the studs in a 10-in. British service gun rifled with a uniform twist, calculated from (17).

Travel of shot.	Total pressure G on base of shot.	Value of C.	Value of R, or total pressure on studs.
ft.	tons.		tons.
0·000	0	·04426	0
0·333	1547	"	68·5
0·945	1077	"	47·7
1·834	781	"	34·6
2·723	621	"	27·5
3·612	510	"	22·6
4·500	424	"	18·7
5·389	356	"	15·8
6·278	305	"	13·5
7·167	268	"	11·8
8·055	240	"	10·6
8·944	220	"	9·7
9·833	205	"	9·1

24. The results in the table show the pressures required to give rotation, if the 10-in. gun be rifled on a uniform twist. I turn now to the rifling as it actually exists, and which is defined to be a parabolic twist, commencing with one turn in 100 calibres and terminating at the distance of 9·833 ft. with a twist of one turn in 40 calibres; and first to determine the equation to the parabola.

Let the origin be at the point where the twist vanishes when the curve AB is sufficiently prolonged—that is, at the vertex of the parabola. Let Oz and Oy' be the axes of co-ordinates; let $OA' = z_1$,

Fig. 2.



$OB' = z_2$; let $\tan\theta_1$ be the tangent of the angle which the curve makes with Oz at A, and $\tan\theta_2$ be the corresponding tangent at B.

Then, from the definition of the parabolic twist,

$$\frac{d^2y'}{dz^2} = \text{constant} = c, \text{ suppose};$$

$$\therefore \frac{dy'}{dz} = cz; \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (21)$$

and

$$y' = \frac{c}{2}z^2. \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (22)$$

But, from (21),

$$\tan\theta_2 = cz_2, \text{ and } \tan\theta_1 = cz_1;$$

$$\therefore c = \frac{\tan\theta_2 - \tan\theta_1}{z_2 - z_1} = \cdot 0047925.$$

Comparing (22) with the form of this equation given in (4), $z^2 = kr\phi$, we have $y' = r\phi$ and $k = \frac{2}{c} = 417{\cdot}3$.

Hence the equation to the development of the parabolic rifling is

$$z^2 = 417{\cdot}3 r\phi, \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (23)$$

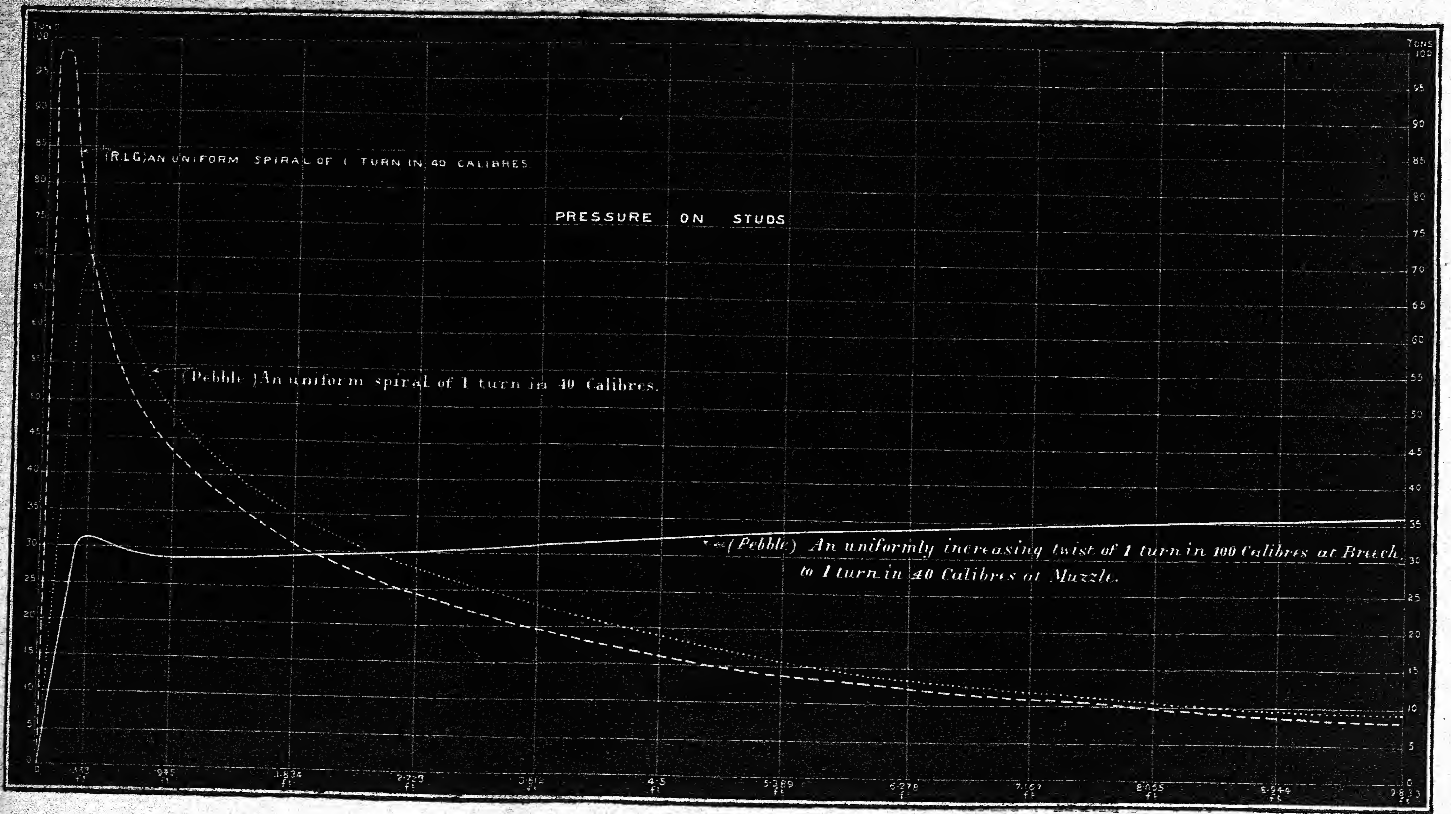
and z_1 the distance of the origin from the commencement of the rifling $= \frac{\tan\theta_1}{c} = 6{\cdot}555$ ft.

25. As in the last case, I place in the form of a table the results given by (15) for different values of z. The values of the constants are, $r = \cdot 417$ ft., $k = 417{\cdot}3$, $\rho = \cdot 312$ ft., $\mu_1 = \cdot 167$, $M = \cdot 00555$.

Table showing the pressure on the studs in a 10-*in. British service gun, rifled with a parabolic twist commencing at one turn in* 100 *calibres and terminating at one turn in* 40 *calibres, calculated from* (15).

Value of z, the distance from the origin.	Corresponding travel of the shot in the bore.	Corresponding velocity of shot.	Total pressure on base of shot.	Value of R, or total pressure on studs.
ft.	ft.	ft.	tons.	tons.
6·555	0·000	0	0	0
6·888	0·333	411	1547	31·2
7·500	0·945	675	1077	28·7
8·389	1·834	873	781	29·0
9·278	2·723	992	621	30·2
10·167	3·612	1078	510	31·4
11·055	4·500	1146	424	32·3
11·944	5·389	1200	356	33·0
12·833	6·278	1245	305	33·8
13·722	7·167	1282	268	34·5
14·610	8·055	1311	240	35·2
15·499	8·944	1333	220	35·8
16·388	9·833	1349	205	36·3

26. From an examination of the values of R given in this table, it will be seen that the total pressure on the driving-surface reaches about 31 tons shortly after the commencement of motion, and the projectile quits the bore with a pressure of about 36 tons. With the view of



PRESSURE ON STUDS
(R.L.G.) AN UNIFORM SPIRAL OF 1 TURN IN 40 CALIBRES
(Pebble) An uniform spiral of 1 turn in 40 Calibres.
(Pebble) An uniformly increasing twist of 1 turn in 100 Calibres at Breech to 1 turn in 40 Calibres at Muzzle.
TONS
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0

making the variations which the pressures undergo more readily comparable, I have laid down in the Plate the curves derived from equations (15) and (17) for the battering charge of pebble powder.

From these diagrams the pressures on the driving-surface at any point of the bore, both for the uniform and parabolic twists, can be seen by simple inspection. The line of abscissæ gives the travel of the shot, and the ordinates give the corresponding *total pressure* on the studs.

The curves show that with the uniform spiral the pressure on the studs reaches nearly 70 tons after a travel of ·3 ft., rapidly falling to about 9 tons at the muzzle; while with the parabolic rifling the pressure at ·3 ft. of travel, corresponding to the point of maximum pressure, is only 31 tons. The pressure then falls slightly, and amounts to 28 tons at about 1 ft. travel; thence it gradually increases to a maximum of 36 tons at the muzzle.

By way of comparison, I have added in the engraving a curve showing the pressures required to give rotation to a 400-lb. projectile fired from the 10-in. gun with uniform twist when R.L.G. instead of pebble powder is used.

The curve in this case is of the same nature as that derived from the pebble powder; but the variation is greater, the maximum pressure being much higher, and the muzzle-pressure, owing to the smaller charge, somewhat less.

27. To one more point it is worth while to call attention.

If the gun were a smooth-bore gun, the equation of motion would be

$$M \cdot \frac{d^2z}{dt^2} = G'; \quad \dots\dots\dots\dots\dots\dots\dots\dots(24)$$

and comparing this equation with (10), we have, on the supposition* that the velocity increments in both cases are equal,

$$G = G' + R \cdot \left\{ \frac{2z \cdot \sin\delta}{\sqrt{4z^2 (\sin\delta)^2 + k^2}} + \frac{\mu_1 k}{\sqrt{4z^2 + k^2}} \right\}, \quad \dots\dots\dots(25)$$

or, in the case of the Woolwich gun, where $\delta = 90°$,

$$G = G' + R \cdot \left\{ \frac{2z + \mu_1 k}{\sqrt{4z^2 + k^2}} \right\}; \quad \dots\dots\dots\dots\dots\dots(26)$$

and the interpretation of these equations is that the gaseous pressure in the rifled guns (rifled with the parabolic twist) is greater than that in the smooth-bored gun by the second term of the right-hand member of the equation.

28. The corresponding equations for a uniform twist are

$$G = G' + R \left\{ \frac{\sin\delta}{\sqrt{k^2 + (\sin\delta)^2}} + \frac{\mu_1 k}{\sqrt{1 + k^2}} \right\}, \quad \dots\dots\dots\dots(27)$$

or, if $\delta = 90°$,

$$G = G' + R \left\{ \frac{\mu_1 k + 1}{\sqrt{1 + k^2}} \right\}. \quad \dots\dots\dots\dots\dots\dots\dots(28)$$

---

* Were the velocity increments not supposed equal, the reduction of pressure due to the suppression of rifling would be less than that given in the text.

29. I shall now put these results in actual figures, and shall again take for illustration the 10-in. gun, supposed (as before) to be rifled, 1st, on the uniform, 2nd, on the parabolic or service twist.

With the uniform twist, G (see table) = 1547 tons; and using equation (28) and the values of the constants given in 22,

$$G' = G - \cdot 245 R$$
$$= \cdot 989 G \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (29)$$

Hence the decrement of pressure due to the suppression of rifling is only about 1 per cent.; that is, the total pressure on the base of the shot is reduced from 1547 tons to 1530 tons, or the bursting pressure is reduced from 19·7 tons per square inch to 19·5 tons per square inch.

At the muzzle of the gun, in the same manner, we find that the total pressure is reduced from 205 tons to 202·8 tons, and the pressure per inch in a corresponding proportion.

30. Similarly, from equation (26) and the values of the constants given in 25, the values of G' at the point of maximum pressure and at the muzzle of the gun are obtained; and I find that with the parabolic twist the pressure on the base of the shot would be reduced from 1547 tons to 1541 tons, or the bursting pressure would be reduced from 19·7 tons to 19·62 tons per square inch.

At the muzzle the corresponding reductions are from 205 tons total pressure, to 196 tons, or from 2·61 tons to 2·49 tons per square inch.

31. For the sake of clearness, I recapitulate the results at which I have arrived. They are as follow:—

1st. That the pressures actually exerted at all points of the bore to give rotation to the 10-in. British service projectile, compared with the pressures which would be exerted were the gun rifled on a uniform twist, are very approximately exhibited in the diagrams on the Plate.

2nd. That in the 10-in. gun (and other guns similarly rifled) the pressure on the studs due to rifling is but a small fraction (about 2¼ per cent.) of the pressure required to give translation to the shot.

3rd. That the substitution of the parabolic for the uniform rifling has reduced by about one-half the maximum pressure on the studs.

4th. That the increment of the gaseous pressure, or the pressure tending to burst the gun, due to rifling is exceedingly small,* both in the case of the uniform and parabolic rifling. This result is entirely confirmed by the experiments of the Explosive Committee, who have found no sensible difference of pressure in the 10-in. gun fired in the rifled and unrifled states.

5th. That, small as the increment in gaseous pressure due to rifling is, it is still less in the parabolic than in the uniform system of rifling.

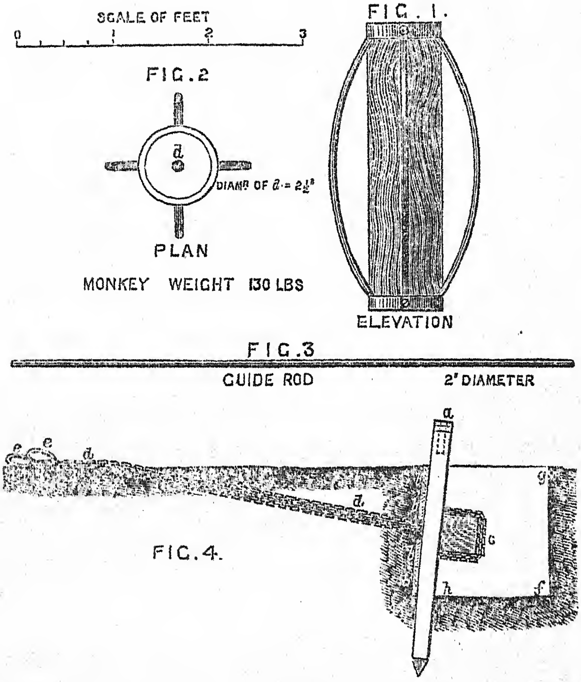
Elswick Works,

February 15, 1873.

* Although the increase of strain due to rifling is inconsiderable, yet the decrease of the strength of the structure of a gun inseparable from rifling may be, and in many systems is, considerable; but the discussion of this question is outside of the scope of my paper.

108. Description of the Swiss Pile-driving Machine.

(Communicated by Major Downes, R.A.)



The "monkey" (Figs. 1 and 2) should be at least 12 ins. in diameter, and about 3 or 4 ft. in length. The handles are made of rope or iron rods, the monkey of wood. Four men can work it easily.

A hole (*d*) of 2½ ins. diameter is bored down the centre of the monkey and burnt smooth.

Each picket to be driven requires to have a hole bored in the centre of the head to a depth of 9 ins. and of 2⅛ ins. diameter. Into this a guiding rod of 2-in. iron 6 ft. long is temporarily placed, and the monkey is worked up and down upon it.

The pickets should have an iron band round the head, to prevent them from splitting.

This appears to be the simplest description of machine for driving the pickets which it is necessary to use when making holdfasts for sheers with which to lift guns of 12 tons and upwards.

The holdfast is thus constructed, agreeably to Minute $\frac{\text{Gen. No. 5}}{5288}$:—

A hole (*b, h, f, g*) 15 ft. × 4 ft. × 4 ft. is dug, and four planks (*b, b, b, b*) placed on edge against the side nearest the points from which the strain is to come.

Four pickets, 8 ft. × 6 ins. diameter (one shown at "*a*"), are driven behind the planks at intervals 3 ft. 6 ins. apart, to a depth of 3 ft. below the bottom of the trench.

One-third of the trench is now filled in, and a beam about 15 ft. × 12 ins. × 12 ins. (*c*)—an old gun will answer—is placed horizontally against the four pickets.

The centre of a chain, 1 in. or more in diameter, is fastened round the centre of the beam, and the two ends are brought between the second and third planks, through a narrow trench cut at right angles to the original one, to the surface; the trenches are then filled in, and the strain taken in the two ends of the chain.

Spars for sheers to lift 25-ton guns should be 45 ft. in length and 20 ins. diameter in centre.

For 12-ton guns, with spars of 45 ft., 17 ins. at the centre; with spars of 40 ft., 16 ins.

109. New Wrought-iron Field Artillery Carriages.

(Communicated by Captain W. Kemmis, R.A.)

A short description of the following field artillery carriages may not prove uninteresting, as they are likely to supersede the present service patterns, in future manufacture, viz. :—

Nature.	Weight empty.	Tonnage.
	cwt. qr. lb.	tons.
9-pr. M.L.R. gun-carriage	10 2 17	4·079
〃 limber	10 3 16	
〃 wagon	14 0 1	4·493
〃 limber	10 3 16	
16-pr. M.L.R. gun-carriage	12 1 24	4·079
〃 limber	11 0 22	
〃 wagon	14 1 13	4·493
〃 limber	11 0 22	

9-pr. M.L.R. Gun-Carriage.

The main points of difference between this and the present service carriage, are as follows:—

The substitution of a wrought-iron for a wooden axletree-bed; the construction of the brackets, in which the plate is placed on the inner instead of the outer side of the bracket frame; and the form and manner of the connection of the trail plate,

The axletree bed, as just stated, is formed wholly of wrought-iron, and has the axletree riveted into it; both together constituting, as it were, a beam of box girder section. The axletree forms the bottom of the box; a piece of angle-iron, riveted along each side of the body of the axletree, the sides; while the top is formed by a broad plate riveted upon the upper sides of the angle-iron pieces. This construction gives great increase of strength; for though the wood bed furnished a convenient means of attachment between the axletree and body of the carriage, it did not support the axletree in an efficient manner.

The brackets are housed over and riveted through their frames to the axletree-bed; they are also secured to it by the front transom, which is riveted to them and to the bed; and, further, by a small bracket stay between each bracket and the back of the bed.

Placing the plate upon the inner instead of the outer side of the bracket frame gives greater strength to the bracket, by bringing the plate more under the trunnions, or, as it may shortly be expressed, "nearer its work." This mode of construction has also the advantage of being the more convenient for manufacture.

The transoms are of plate-iron; the front transom has a frame of angle-iron riveted to it in front, and a piece of angle-iron along each side in rear; and the second transom has a piece of angle-iron riveted along each side, both front and rear.

The trail-piece is formed, not as in the present service carriage, to lap over and under the point of the trail, but to lie partially between the bracket sides. This form gives a stronger neck to the trail eye, and is much easier of manufacture than the old pattern. A bearing plate is bolted beneath the point of the trail.

The top plate of the axletree-bed forms a suitable support for the axletree-boxes, which are attached to it by nib irons on the inner and screws on the outer side.

The wheels of the carriage are the same as those of the present service carriage—viz., Madras pattern, of the 2nd class, 5 ft. high, and with a tire $2\frac{1}{2}$ ins. wide.

The elevating screw box is secured in its sockets on the brackets by cap squares, which makes it more convenient for removal, when required.

The other fittings and articles belonging to the carriage are similar to those of the present service carriage.

9-pr. M.L.R. Limber.

This limber differs from the service limber in having a wrought-iron instead of a wooden axletree-bed, and no block between the latter and the limber-hook.

The axletree-bed is formed in a similar manner to that of the gun-carriage, but being of necessity deeper than the latter, its sides are constructed of plate-iron, a piece of angle-iron being riveted along each for the top plate to rest upon and be secured to.

The futchells, of tee-iron, are let into the bed beneath the top plate, and are riveted to its angle-iron. The centre futchell is bent and its end riveted to the back plate of the bed, while the outer futchells project to the rear for the support of the top plate under the limber boxes; the latter plate is also strengthened by a stay near each end.

The limber-hook is forged with three long arms by which it is riveted to, and at the same time held at a sufficient distance from, the rear of the bed; the rivets holding the upper arms have collars upon them.

The platform and footboards are both 10 ins. wide, and beneath the front of the latter a slat is secured across the futchells, to prevent a horse getting his leg between the splinter bar and the board.

The splinter bar is of plate-iron, trough-shaped, as in the service limber.

The wheels, fittings, and articles belonging to the limber are also the same as in the latter.

9-pr. M.L.R. Ammunition Wagon.

This wagon differs very considerably in its construction from the present service pattern. Its axletree-bed is of wrought-iron, built up in the same manner as that of the gun-carriage—namely, by angle-iron riveted along each side of the body of the axletree, and a plate over the angle-iron pieces.

The perch is formed of two brackets, in a somewhat similar manner to the trail of the gun-carriage, connected by a nose-piece with eye for attachment to the limber, and by three collar bolts. The nose-piece is formed in the same manner as the trail-piece of the gun-carriage. The brackets are of channel iron, the trough or channel in each being turned outwards, and in rear of the axletree-bed the lower part sloped off. This form of perch gives greater strength against any twisting strain.

The perch lies across the top plate of the bed, each bracket of the former being connected to the latter by a piece of angle-iron riveted to both, and also by rivets through the lower flange of the channel-iron.

The sides of the wagon are of angle-iron, fish-bellied; they rest upon the axletree-bed, and are connected to it by means of angle-iron. To the outside of each side, and to the bed, is also riveted a stay of angle-iron, which forms, as it were, the continuation of the top plate of the bed.

A platform plate is riveted across the perch and sides beneath the front and rear platform boards.

The wheels and the boards are the same as in the service pattern wagon.

The block for the axletree arm to carry the spare wheel is formed by riveting a plate to the inside of each bracket, and projecting upwards from it. The plates are connected by two collar bolts, and have the arm, which is of wrought-iron, solid, riveted between their upper extremities. Upon the perch, extending under the footboard, the usual wooden stay is riveted.

The other fittings and articles belonging to the wagon are the same as in the present service pattern.

16-pr. M.L.R. Gun-Carriage, &c.

The 16-pr. gun-carriage is similar to that of the 9-pr., but has heavy instead of light field wheels—*i.e.*, with a tire 3 ins. wide instead of $2\frac{1}{2}$ ins., and is fitted with a trail box.

The limber and ammunition wagon are identical with those of the 9-pr., except in having heavy wheels, and in the internal fittings of the boxes.

ERRATUM.

Page 168, sec. 107, heading, *for* "Fuze, Time, Wood, R.M.L. Ordnance," *read* "Fuzes, Time, Wood, Boxer, M.L., 20 secs. and 5 secs., Mark III."

PRINCIPLES

OF

CONSTRUCTION OF WHEELS AND AXLETREES.

BY

CAPTAIN W. KEMMIS, R.A.

The "object" of using wheels is to lessen the resistance to the movement of a carriage over the ground, by converting that resistance from one of "sliding" friction, or the friction of a surface of contact, to one of "rolling" friction, or the friction of a line of contact.

When wheels are used, rolling friction is developed not only between them and the carriage body—that is, between their pipe-boxes and the axletree-arms—but also between them and the ground; the first mentioned portion of the friction alone resists the movement of the carriage, the second prevents the wheel from sliding.

The wheel, in carrying out its object, attains, from its form, some minor advantages, thus:—Suppose, for simplicity, the carriage standing on the level, and power applied to move it at the axis of the axletree in a direction perpendicular to the latter and parallel to the ground; then, the friction between the pipe-box and axle, which tends to prevent the wheel turning, acts with a leverage equal to the radius of the pipe-box, while the power making the wheel to roll acts with a leverage equal to the radius of the wheel; thus the power has an advantage over the friction in the proportion of the radius of the wheel to that of the axle. Again, if the wheel meets a small obstacle in its path, the power, with regard to that obstacle, has a greater leverage, measured by the perpendicular let fall from the point of contact upon its direction, than the resistance of the weight, measured in a similar manner. This gain is true, as stated, with regard to small obstacles only; when the height of an obstacle exceeds a certain limit, it is manifest that the gain no longer holds good. If the obstacle, instead of being raised, be in the form of a transverse rut, the wheel gives a further advantage, proportional to its radius, in spanning the rut.

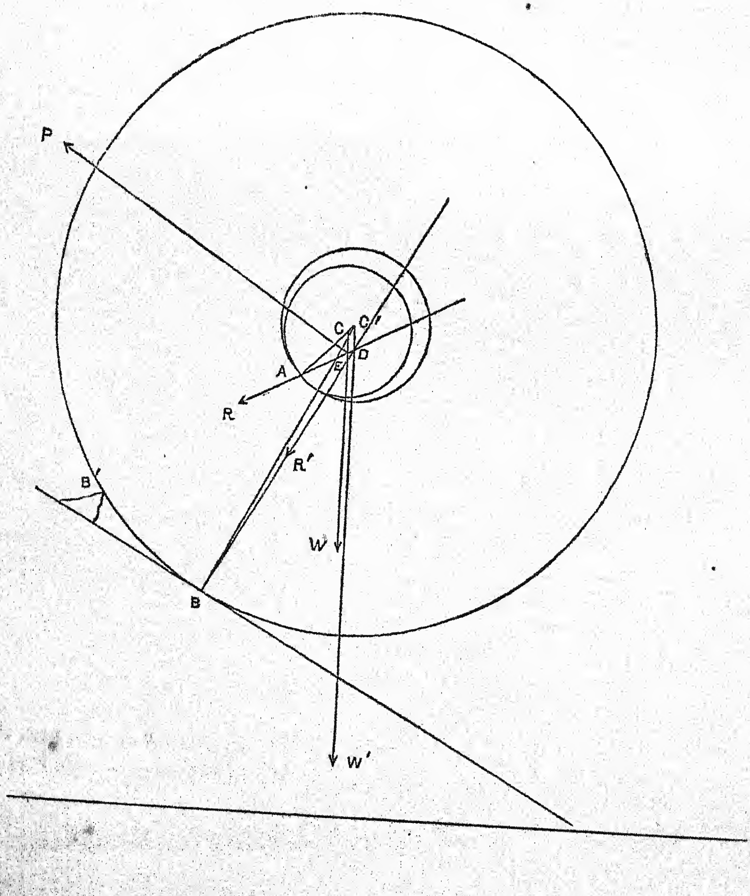
Setting aside special obstacles in a road to the motion of a wheel, certain what may be called imperfections exist in every road, which, as well as irregularity of form in the wheel itself, oppose some resistance to rolling. Such imperfections are: unevenness of surface, want of

perfect hardness, and want of perfect elasticity. The first defect causes obstacles to be presented to the wheel at each instant; the second—want of perfect hardness—causes the ground to yield, so that the wheel in its onward progress is continually opposed by the materials of the road immediately in its front. In the case of a perfectly elastic road, this would be of no consequence; for the compressed materials, as the wheel passed over them, would expand again just so much as compressed, and in so doing would react upon the wheel in rear with the same amount of force as expended by the wheel in compressing them.

The relations between the forces which act upon the wheel and axle are shown in Fig. 1, and may briefly be stated as follows:—

W = half weight of axle and load,
W' = weight of wheel,
P = traction or power, its direction making an angle β with the horizontal,
ϕ = limiting angle of resistance between the pipe-box and wheel,
γ = angle of slope of the ground.

Fig. 1.



Let C and C' be the centres respectively of the axle and wheel, A the point of contact between the axle and pipe-box, B the point of contact between the wheel and ground; also, let the direction of the power meet the vertical through the centre of the axle in E. The forces acting upon the axle are P, W, and the resistance of the pipe-box. P and W have a certain resultant; let it be R, and let the angle its direction makes with the vertical be θ. Supposing the axle to be in a state of equilibrium, the resistance opposed by the bearing of the pipe-box must be equal and opposite to R; and further, supposing the axle to be just on the point of motion, the direction of the resistance must make an angle ϕ with the normal to the point of contact. Hence, we have the angle $EAC = \phi$, and the following relations, viz. :—

$$P \cos \beta = R \sin \theta, \quad \text{..........................(1)}$$

$$P \sin \beta + R \cos \theta = W. \quad \text{..................................(2)}$$

The forces acting upon the wheel, are the pressure on the pipe-box, the weight of the wheel, and the resistance of the ground. Supposing the wheel to be in a state of equilibrium, the resultant of the first two must pass through B—the point of contact between the wheel and the ground. Calling the resultant R', and denoting the angle its direction makes with the vertical by θ', we have the following relations, viz. :—

$$R \sin \theta = R' \sin \theta', \quad \text{..........................(3)}$$

$$R \cos \theta + W' = R' \cos \theta'. \quad \text{..........................(4)}$$

Also,

$$\sin \theta = \sin \phi \cdot \frac{AC}{CE},$$

and

$$\frac{AC}{CE} = \frac{AC'}{C'D} = \frac{AC'}{C'B} \cdot \frac{C'B}{C'D} = \frac{AC'}{C'B} \cdot \frac{\sin \theta'}{\sin (\theta' - \gamma)};$$

therefore,

$$\sin \theta = \frac{AC'}{C'B} \cdot \frac{\sin \theta' \cdot \sin \phi}{\sin (\theta' - \gamma)}. \quad \text{..........................(5)}$$

In order that the wheel may roll, it is only necessary that the direction of R' should fall to the left of the point B, instead of passing through it.

If the wheel meet an obstacle, as at B', the effect, when the wheel is on the point of surmounting it, is merely to change the point of contact from B to B', and increase the angle θ' by an angle BDB'.

Wheels in the service are classed according to the size of the pipe-box—viz., first (or siege), second (or field), third (or transport), and special. The scantling of the material for each particular part of a wheel is fixed for the class, the dimensions determined upon in each case being the results of experience.

Passing on now to consider the component parts of the wheel in detail, and commencing with the nave, we see, from what has been said about friction, that the more play there is allowed between the pipe-box and the axletree-arm (that is, the greater the difference of their radii),

the less will be the amount of the friction developed between them. But, in opposition to this, there is the consideration that, should there be any cross action of the pipe-box on the arm, it should be allowed as little room for action as possible. To this latter, practically, attention is mainly directed, and only sufficient play is given to ensure freedom in working. The length of the pipe-box must be such as to give the wheel proper stability upon its arm, and also to furnish, besides enough grease recess, sufficient frictional bearings to prevent too rapid wear. A hard alloy, technically known as "metal," is now used as the material for pipe-boxes in preference to cast-iron, on account of the less development of friction between it and the iron arm.

For the flanges of the naves of artillery wheels metal is also employed, but of a softer nature than that used for pipe-boxes. In the naves of wheels for transport service the flanges are of wrought-iron, as being lighter, for the same strength, than metal.

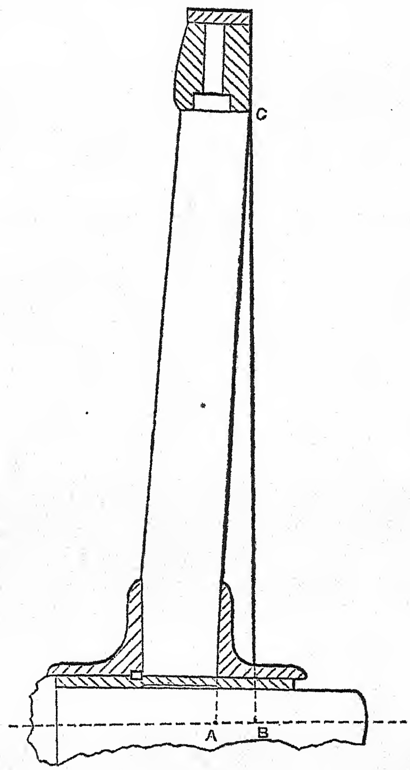
The position of the feet of the spokes in the nave is a point of importance. It must be such that, when the wheel is completed and on its carriage, the perpendicular from the centre of resistance, or centre of the bearing part of the tire on the ground, should pass within the cross-section of the lower or "working" spoke through the centre of pressure, in order that there may not be any cross action of the pipe-box on the axletree-arm. The centre of pressure is usually taken as represented by the central point of the axis of the pipe-box, though in reality it lies inside of this point.

A defect in the wood nave, as compared with the metal or Madras pattern nave, deserves here to be mentioned. In the former, from the mode of manufacture, more or less vacant space is always left between the feet of the spokes and the pipe-box; consequently, when the wood shrinks, the mortises enlarge, giving the spokes opportunity of entering further into them. When this is the case, as the wheel revolves and each spoke in succession becomes a working spoke, it will be pressed as far as it can go into the stock; while the spokes which for the time are upper, will be rather drawn out from the stock. Thus, as the wheel continuously rolls, the spokes will work in and out of the nave, and the wheel cannot last.

Spokes, for strength, are made of oak; and to ensure the proper direction of the fibre, are cleft from the tree. From the latter circumstance, they shew on their deeper sides that appearance of the fibre which is termed the "felt." The most severe stress to which spokes are subject, is from the lateral thrust brought to bear upon the nave when one wheel becomes lower than the other by dipping into a rut, &c. In order, therefore, to place them in a better position to resist this thrust, the wheel is "dished," or formed into a kind of dome; and just as the dome or arch is strong, from its form, to resist pressure upon the crown tending to crush it in, so is the wheel made strong by the dish to resist the lateral thrust tending to force the nave outwards. In fact, not only do the spokes, sustained by the tire, yield mutual support to each other, but the lateral thrust upon each becomes partly converted into a compressing strain, which the wood has better power to resist. The greater the dish, the stronger the wheel will be to resist the lateral

strain; but, for other reasons to be mentioned further on, no more dish should be given than necessary for the safety of the spokes. The amount of dish in a wheel is measured along its axis, from the point *A* (Fig. 2), where the prolongation of the face of the spoke meets that

Fig. 2.



axis, to the point *B*, where the perpendicular let fall from the extremity of the face at the bosom of the felloe meets the same axis. This in the O.P. field wheel of 5 ft. diameter is 3·375 ins. (measured close above the nave instead of along the axis it amounts to 2½ ins., and hence is usually, though incorrectly, said to be ½ in. to 1 ft.) In the N.P. field wheel, the dish has been reduced to 2 ins., and experiment has shown that it cannot be further reduced with safety to the spokes, except in some cases, where the dish of a low front wheel is made to suit the track of the hind wheel. The amount of dish in wheels not of 5 ft. diameter is proportional to that in the 5 ft. wheel (that is, to 3·375 ins. if O.P., and to 2 ins. if N.P.), for the relative lengths from the axis to the bosom of the felloe.

Dishing a wheel carries with it some minor advantages—for instance, giving greater width between the wheels above the axletree

for the load; and one great disadvantage—namely, the bevelling of the sole of the wheel, which is brought about by the necessity, consequent upon the dish, of having to set the axletree-arm at an angle downwards. The bevelling makes the wheel conical in form, instead of cylindrical. Now a cone, we know, if set in motion on the level, will describe a circular path round its apex as centre; so the wheel, if set in motion and free, would describe a circular path round the point where the prolongation of its sole would meet the prolongation of its axis—or, in other words, where the latter would meet the ground. On the carriage, the wheel is compelled to move straight forward, in a path unnatural to it; and consequently, instead of rolling it partly slides, thereby, as it were, giving a frictional surface between the ground and the body moved, and tending to defeat the primary object of using wheels.

The dish of a wheel is measured practically by laying a straight-edge across the face of the wheel, just above the nave, and measuring the perpendicular distance from it to the foot of the spoke; which distance should agree with the same calculated by similar triangles, or with a similar measurement on a wheel of the same nature whose dish is known to be correct.

Ash, as a strong elastic wood, is used for felloes. The number of felloes in a wheel is fixed by the consideration that the length of each must not be so great as to necessitate the fibre of the wood being much cut across in shaping the felloe; and, at the same time, the fewer the felloes there are, the better for the strength of the wheel, as the junction between every two is a weak point. In the 5-ft. wheel six felloes is the approved number, each receiving two spokes. It is usual to cut felloes to a larger radius than that of the wheel for which they are intended, to prevent their extremities afterwards drooping; and from this circumstance a new wheel does not form a perfect circle.

With regard to the tire, which is of wrought-iron, its width to some extent depends upon the scantling of the felloes; but is mainly governed by the considerations that it ought to be at a maximum for passing over yielding ground, and at a minimum for lightness. With regard to the latter point, its thickness also should be at a minimum consistent with strength. Comparing the "ring" tire with the "streak" tire, we see that the former gives much better support to the other parts of the wheel; but in the case of a wooden nave, should the latter shrink, it cannot follow up the movement of the spokes mentioned before, which the streak tire (there being a small space between the ends of the streaks, and the bolts holding it being capable of yielding a little), to a certain extent can, and thus diminish the play of the spokes. The streak tire also admits of readier repair, should a felloe be damaged; but, on the other hand, on account of the number of bolts and rivets through the felloe, weakens the latter more than the ring tire, when one or at most two bolts are required.

The considerations which govern the height, or diameter, of a wheel are the following:—It should be at a maximum, in order to carry out as completely as possible the object and advantages in view of which wheels are used; but increase of diameter carries with it increase of weight and cost, and also decrease of stability, and entails, in the case of a gun-carriage wheel, greater inertia to recoil. There are cases, however—as with the

M.L.R. field guns and carriages—in which inertia to recoil in the wheels is a desideratum, providing their strength admits of their accepting it. Further, the height of the shafts and convenience of loading must be taken into consideration in determining the diameter of a wheel. In the field wheel, and other wheels for ordinary purposes, the height of 5 ft. has been adopted, as best fulfilling the above conditions; in other wheels the height is varied to suit special requirements.

With regard to the weight of a wheel, it should be at a minimum, provided the strength is sufficient, to increase the mobility and diminish (in the case of a gun-carriage) the inertia of recoil; but, as before said, there are cases in which it is advantageous to increase the inertia. It is further convenient, when circumstances admit of it, to have the weight not greater than two men can lift.

Wrought-iron is employed as the material for axletrees, on account of its strength and toughness. If for use with wheels having cast-iron pipe-boxes, the arms are steeled, to prevent too rapid wear.

The general dimensions of an axletree depend, naturally, upon the weight and nature of the load which it has to support. Its cross section is kept at a minimum, consistent with strength, for the sake of lightness, and also in the arms, in order that what friction is produced between them and the wheels may have as small a leverage in its favour as possible.

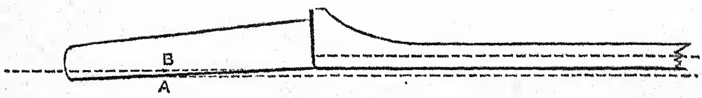
In axletrees bedded in wood, the body of the axle is made rectangular in cross section, that there may be better hold or union between the axle and the bed. In the later patterns of transport wagons, wood beds have been dispensed with, as inconvenient and superfluous. In these carriages the whole strain, whether vertical or horizontal, is applied close to the shoulder of the axletree, and the body within these straining points is relieved; hence a smaller section is admissible for the latter, and as it has no strain in any particular direction, as well as for convenience, its form is generally circular. A downward inclination or "hollow" is given to the axletree-arm, in order to bring the lower spoke vertical when it comes immediately under the arm, the wheels being on the level; otherwise, owing to the dish of the wheel, it would be in a bad position—in fact, the perpendicular from centre of resistance would not pass through centre of pressure in the pipe-box. When, under the above conditions, the working spoke is not brought quite vertical, but at an angle outwards to the vertical, the wheel is said to have a "strut," the amount of which is expressed in inches, and measured along the axis of the wheel from the point where the prolongation of the face of the spoke meets it, to the point where the vertical drawn from the extremity of the face at the bosom of the felloe meets the same axis.

Though, on the level, giving a strut to the wheel is slightly disadvantageous, on the whole a certain amount of strut is decidedly good, as assisting the wheel—or rather its lower or working spoke—under the most trying circumstances, when it dips into a rut, &c. Formerly, most wheels had more or less strut; for instance, the field wheel had about 1 in. At present, no strut is given in the N.P. field wheel, but ½ in. in the 5-ft. wheel for transport carriages, and to others for the same service in proportion.

It will be seen from the foregoing that the amount of hollow given depends entirely upon the dish of the wheel, together with the amount of strut it is desired to give.

The hollow is expressed in parts of an inch, and measured as the perpendicular distance from a point *A* (Fig. 3), in the under edge of the

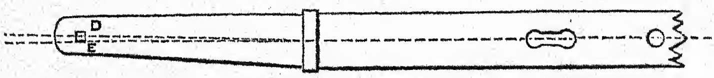
Fig. 3.



arm, distant from the shoulder the length of the pipe-box, to a point *B*, in a line drawn parallel to the axis of the body, and touching the lowest point of the base of the arm. This manner of reckoning the hollow, though convenient, is not strictly correct, as it takes into account the amount of cone of the arm. Practically, the hollow may be measured with sufficient exactness by stretching a string from one linchpin-hole to the other, on the under side, and measuring the distance from the string to the base of the arm. The amount of the hollow is always such as to point the arm downwards, notwithstanding its conical form; which has the effect of relieving the washer and linchpin of the pressure which the nave would otherwise have against them, due to the tendency of the wheel to roll outwards.

In addition to the "hollow," an inclination to the front, or "lead," is given to the axletree-arm, in order to place the front part of the wheel, as in revolving it approaches the ground, more in the direction in which the wheel is intended to travel, and from which the hollow of the arm, as well as the dish of the wheel, make it to deviate. The lead thus causes the wheel to meet any obstacle which opposes it more directly, as regards the spoke on which the stress due to the resistance of the obstacle happens mainly to fall; in fact, it does for that spoke what the hollow does for the lower spoke. Strictly speaking, the amount of the lead should be proportional to the dish of the wheel; being, however, small, it has been empirically fixed at $\frac{1}{16}$ in., and is measured in the same manner as the hollow (Fig. 4).

Fig. 4.



It will be seen from the preceding remarks upon the wheel and axletree, that in planning the former, after its general dimensions have been fixed, the amount of "dish" and of "strut" have to be determined; from which follow the amount of "hollow" of the axletree-arm, and then from the latter the amount of bevel of the sole of the wheel.

RIFLING FOR HEAVY GUNS.

BY

MAJOR J. P. MORGAN, R.A.,

ASSISTANT SUPERINTENDENT ROYAL GUNPOWDER FACTORIES.

(*Reprinted, by permission, from the "Journal of the Royal United Service Institution," Vol. XVII., p.* 645.)

THE principles of rotation are very recondite, and have been the subject of some abstruse investigation; but it is not necessary to consider them mathematically in order to understand their application to the rifling of guns.

They may be briefly stated as follows:—

In every rigid body there are "three principal axes," about which the body is capable of rotating permanently.

Two of these, the greatest and the least, are "stable axes of rotation" —*i.e.*, if the body rotate round an axis having a very small inclination to either of these axes, it will continue to rotate without further divergence. The medium principal axis is an "unstable" axis of rotation—*i.e.*, if the body rotate round that axis exactly, it will continue to do so; but if the axis of rotation be inclined to it in the very least, the inclination will become greater and greater. With these exceptions, the body will not rotate permanently round any axis, but in all cases the axis will change its position in the body until, at last, the rotation is round its shortest axis, which is the most stable of all.

When a body rotates round a stable axis, and is not acted upon by impressed forces, the axis of rotation not only retains its position in the body, but also in space, by always remaining parallel to itself. If, therefore, there was no resistance of the air to an elongated projectile after leaving a gun, the question would be very simple; for all that would be necessary would be to give a comparatively feeble rotation round the longest axis, and the shot, by virtue of the rotation imparted, would go nearly point foremost for a considerable part of its trajectory. It would not, however, be possible to make the projectile strike point foremost at very long ranges *in vacuo;* and when we find, therefore, in practice, that it is possible to make rifled projectiles strike point fore-

most, even at very long ranges, we infer that this is due to the resistance of the air, and are led, not only to consider the causes which produce this result, but the *simplest* method of obtaining it. It cannot be due, as some suppose, to the tendency of the projectile to take that position which gives least resistance; for then there would be no necessity to give any rifling at all. The laws which regulate the action of impressed forces on a rotating body have been pretty well determined; and though they do not—owing to the difficulty of determining the resultant action of the resistance of the air—enable us to solve this question theoretically, they give great aid in drawing correct conclusions from observations derived from experiment. Whatever be the action of the resistance of the air, we know that it can be represented by two forces, one of which acts through the centre of gravity of the projectile and tends to produce a change in its velocity and direction, while the other tends to produce rotation round some axis, and thus tends to produce a change either in the direction of the axis or in the velocity of rotation, or both.

The latter of these two forces will be considered more particularly.

It is a law in mechanics that if a rotating body, whose axis and velocity of rotation are represented in direction and amount by a straight line, be acted on by forces which would produce another rotation whose axis and velocity may be similarly represented by another straight line, the result is a rotation whose axis and velocity may be similarly represented by a straight line forming the diagonal of the parallelogram of which the two straight lines are the sides. All these lines pass through the centre of gravity of the body. If the axis of rotation be a stable axis, and the forces be gradually applied, the axis does not change its position in the body, but only in space, and the amount of change is proportional to the amount of force applied, compared with the force which would produce the original rotation.

This law may be illustrated by the gyroscope. If the gyroscope receive a rotation which to the spectator is seen to be in the direction of the hands of a clock, it may be represented by a straight line drawn in the direction of the axis towards the spectator. If now a weight be hung at the extremity of the axis towards the spectator, this tends to produce a rotation which may be represented by a straight line drawn from the gyroscope to the left; the result is, that the axis takes up a new position between the two, and moves to the left. If the weight be hung at the extremity of the axis from the spectator, the tendency to produce rotation will be represented by a line drawn to the right, and the axis will move to the right. So long as the weight is suspended, the deflection continues, and it ceases when the weight is removed. It will be observed that when the rotation is considerable and the weight not too heavy, the deflection is almost exactly to the right or left; but if the rotation be low or the weight considerable, there is also a tendency in the point of suspension to drop, so that at each gyration it descends lower and lower. This fact should be particularly borne in mind, as it explains why it is necessary to give a considerable rotation to rifled projectiles.

Another illustration may be given by the spinning of a top. The

axis round which rotation is given is a principal axis, and thus there is no tendency to change its position in the top. If, when the point comes down on the ground, the axis is vertical, the top will at once spin steadily on the ground. Usually, however, the axis is inclined to the horizontal, and the weight of the top, acting through its centre of gravity, tends to produce a rotation round an axis perpendicular to the axis of the top. The position of the axis thus changes; and at first the point describes large circles, rolling on the ground, the axis always being inclined inwards. When the point has become fixed in one place, the top describes complete gyrations. A peculiar motion is then observed; for the gyrations become smaller and smaller, until the top spins on a vertical axis, or "sleeps," as it is called. This is due to the friction of the point on the ground, which a little consideration will show ought to produce this effect. As, however, the rotation becomes slower, the top begins again to gyrate, and, in spite of the friction on the ground, the gyrations become larger and larger, until the point begins to describe small circles on the ground, and the top wabbles. This last sort of motion very well represents the motion of a free rigid body rotating under the influence of impressed forces of comparable magnitude; and, as we shall see, has to be considered in the case of rifled projectiles as they move through the air.

The motion of the earth, which produces what is called the precession of the equinoxes, is another illustration of the same sort of motion. The shape of the earth is that of an oblate spheroid, and may be considered as a sphere enclosed in a hollow shell, which is thickest at the equator and tapers off towards the poles. The attraction of the sun on the sphere has no tendency to produce rotation; but, on the shell, the attraction of the sun is greater on the half nearer than on the half more remote. The resultant action is a tendency to draw the equator into the plane of the ecliptic, and produce a rotation round an axis perpendicular to that round which the earth rotates. The consequence is that the earth describes a huge gyration, once in about 25,000 years, similar to the top in its final stages, but in the opposite direction. For it will be observed, that whereas the weight of the top tends to increase the angle at the apex of the cone of gyration, the attraction of the sun on the earth tends to diminish it; and we should expect to find, also, if observations could be made for the gigantic period that would be necessary, that the obliquity of the ecliptic is gradually becoming less and less. To this cause the glacial periods which seem to have covered the whole surface of the globe, may possibly be due; for if the obliquity be becoming less, it must at one time have been greater than it now is, and if the obliquity at one time has been very great, it would be sufficient to account for extreme heat and cold, every year, all over the globe. There is another action which, like the friction of the peg of the top, tends to retard the rotation of the earth—viz., the friction of the tides, which Meyer, in an elaborate calculation, has endeavoured to show is at present compensated for by the contraction of the bulk of the globe. The ultimate result must be, if sufficient time be allowed, that the earth will present only one side to the sun—a condition which we find in the case of the moon with regard to the earth, and

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which Mr. Rigg has supposed has been brought about by a similar cause. Doubtless, also, the fluid interior of the globe will exercise a disturbing influence; and considering that the laws which govern a fluid body in rotation under the influence of impressed forces differ in the results produced by them in the case of a rigid body, it is possible that the axes of rotation of the two are not coincident, but that there is a friction between the two surfaces which produces the magnetism of the earth, and also may be the cause of the periodic risings and subsidences of the crust of the globe so well known to geologists, because thus the two equators would be continually altering their positions with regard to each other. The effect of the laws of rotation on the solid and fluid portions of the globe is an interesting speculation, which cannot, however, be carried into the dark future, seeing that we are met with the prediction that our earth is not destined to last for ever. The three laws—heat, elasticity, and attraction of gravitation—were given to matter in the first three days of creation. The law of heat appears to be the only one which is fading away; but the promise is, "yet once again I shake the heavens and the earth," which not only appears to establish the undulatory theory of heat, but also may explain the other statement that "the elements shall melt with fervent heat," or be dissipated by intense incandescence into space, possibly again, under the influence of these same laws, to form new worlds, in the way La Place has shown the universe to have been made.

Seeing, therefore, that the laws of rotation exist, not only in theory, but in undoubted fact, no explanation of the motion of a rifled projectile can be considered satisfactory which leaves them out of account.

If the shot come out of the gun perfectly centred—*i.e.*, rotating round its longest axis, and having that axis coincident with the line of flight—there will be no tendency either of the axis of rotation or of the projectile itself to deflect, so long as the motion is in a straight line, because the resistance of the air will act uniformly all round. As soon, however, as the trajectory has begun to curve downwards under the influence of gravity, the resistance of the air acts more on the under side than on the upper, and effects will be produced depending on the resultant direction of the resistance of the air in relation to the centre of gravity. If, as in the case of service projectiles, the resultant action be through a point of the axis in front of the centre of gravity, the shot will commence to gyrate in the same direction as a top, and the resistance of the air, acting on the exposed side of the projectile, will cause it to be carried bodily from the trajectory in the direction of the deflection of the point; but if the resultant act through a point behind the centre of gravity, as is supposed to be the case with cylindrical shot,* the gyration will be in the same direction as that of the earth, with a corresponding deflection of the shot. In both cases the tendency is to gyrate round the trajectory.

The rate of the gyration will depend on two things—viz., the amount of original rotation given to the shot, and the amount of force tending to

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* "Proceedings O.S.C.," 9th May, 1864, Minutes 11,804 and 11,805.

produce a second rotation round an axis perpendicular to the first. If the amount of original rotation be low, the shot will begin to gyrate with a smaller deflection of axis than if the rotation be great. A low rotation, therefore, is to be preferred to a high rotation, as keeping the point closer to the trajectory. There are some causes, however, which interfere with the possibility of giving a very low rotation. In the case of the top, we have seen that, when the rotation is low, the gyrations become larger and larger. The same is to be observed in firing rifled service shot with too low rotations. They seem to go steadily at first, but afterwards begin to wabble as they proceed. In the case of the top, we saw that the friction of the peg on the ground tended to diminish the size of the gyrations, but in the case both of cylindrical* and service shot, the friction of the air tends to increase their size; for, according to the principles investigated by Robins and Magnus, the rotating surface carries with it a current of air which meets the resistance of the air in different directions, and the side of the head which leads the gyration and is rotating inwards, meets a greater resistance than the opposite side which is rotating outwards. In order, therefore, that the gyrations may not become too large before the end of the trajectory is reached, a sufficient amount of rotation must be given. The exact amount required is a matter well worthy of consideration, and varies in different guns, not only according to the length and diameter of the projectile, but also according to the amount of "centring" the shot has when it leaves the gun. With equal masses, the relative stabilities of shot varying in length may be expressed inversely as the twist in calibres; but the longer projectile allows the resistance of the air to act with a greater leverage,† and increased rotation must be given to compensate for this. After the necessary allowance has been made, the main cause which prevents a very low rotation being given is, that a shot rarely ever leaves the gun exactly centred. If the shot come out not centred, but having an initial deflection of the axis, it at once commences to gyrate, and that also at the time when the resistance of the air is the greatest; so that when a properly centred projectile may be only at its first gyration, a projectile not properly centred may have reached its second or third, under the adverse circumstances of increased resistance of the air which the other would have escaped. In order, therefore, to prevent the large gyrations being attained too soon, an increased rotation has to be given.

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* "Proceedings O.S.C.," 19th September, 1862, Minute 7381; and 8th May, 1863, Minute 9015. The greater unsteadiness of cylindrical shot compared with service shot is probably caused by the fact that the flat head causes greater resistance of the air, and the friction acts at a greater leverage. This is not inconsistent with the supposition that cylindrical flat-headed shot deflect to the left; because, though the resultant action of the resistance of the air might act behind the centre of gravity, the action of the friction would probably still be felt most at the head, where the air was most, though uniformly, condensed all round. The true deflection of flat-headed projectiles cannot as yet be said to be satisfactorily determined.

† This greater leverage is, however, compensated by the smaller surface of the head which is exposed to the resistance of the air. It is probable, however, that the leverage increases more rapidly than the length of the shot. With the Snider bullet the resultant action of the resistance of the air must have acted very nearly through the centre of gravity, otherwise the low spin would not have been sufficient to ensure the tolerable accuracy of fire which has been obtained from it.

The bad shooting of the original Lancaster gun is an illustration of the effects of want of centring. The outrageous system of rifling, together with the badly fitting projectile which was adopted in this gun originally, made it an impossibility for the shot to come out properly centred. The consequence was that the practice made by it was most erratic, even with very high velocities, and the very considerable rotation which was given. The path of the projectile could be traced by the eye as it described a sort of spiral, sinuous, or corkscrew motion, at one time deflecting to the right, at another to the left, and so on. Very much better shooting has been obtained from guns with one-third of the twist, and there can be no doubt that the reason is to be found in the fact that they delivered their projectiles better centred.

It is a curious fact that, with our service projectiles, the deflection is always to the right; and to this, no doubt, is due the accuracy of fire which is obtained with them; for if at one time they should deflect to the right, and at another to the left, it would hardly be possible to make accurate practice. A very crude theory, which has found considerable acceptance, has arisen from this fact. It is that "a shot rotating rapidly, and at the same time falling in the air, will experience a greater pressure underneath than above, and will therefore roll, as it were, on the denser air below." That this cannot be the case is at once evident, when we remember that, according to the principles determined by Robins and Magnus in the case of round shot, it ought to produce a deflection in exactly the opposite direction; and, if it were the true reason, our service rifled shot ought to deflect to the left instead of to the right.

Professor Bashforth offers a better explanation in his valuable book on the "Motion of Projectiles," recently published. He says (p. 65):—"The shot will have a sinuous motion. But as the *first* deflection of an ogival-headed shot spinning with right-handed rotation is to the right, and afterwards, as its point is directed more to the right than to the left, the shot will have a deviation on the whole greater to the right than to the left."

By plotting some very accurate practice made with a B.L. 40-pr. Armstrong gun—* which is perhaps the most accurate shooting gun we have ever had in the service—it will be seen how the deflections vary. There is little or no deflection up to 700 or 800 yds. Then the deflection begins to be appreciable, and increases up to about 1200 yds., when the rate of deflection appears to attain a maximum. After that, the rate of deflection to the right decreases, but no deflection in the opposite direction to the left can be traced. From about 1500 to 2000 yds., or more, there appears to be very little tendency to deflect at all; but beyond that, the deflection to the right begins again to manifest itself, and at about 2500 yds. range it has again attained a maximum to the right, gradually after that diminishing, and, at more than 3000 yds., showing some symptoms of deflection to the left.

The following diagram will very well represent the deflection of the

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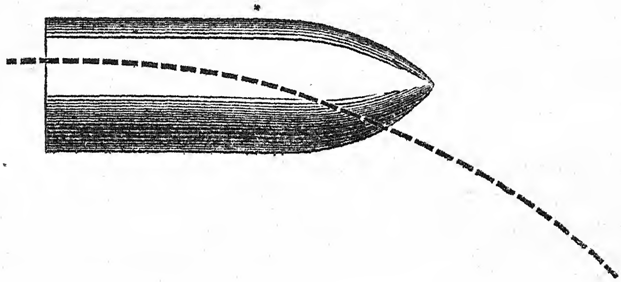
* "Proceedings O.S.C.," 22nd October, 1862, Minute 7634.

point in this instance, both in accordance with the facts observed and with the laws of rotation already noticed.



The concentric circles represent the base of the shot, and the dark spiral line the supposed deflection of the point. The eye is supposed to be looking always in a line tangential to the trajectory. The dotted line is the course the point would take were the trajectory to be prolonged beyond the usual ranges, or which it would take were the shot

not properly centred. The reason of this somewhat curious but very valuable motion of the point, appears to be due to the fact that the dip of the trajectory materially interferes with the tendency to gyrate. As the point is gyrating downward, the trajectory is also curving downwards, and it is the comparative rates of these two motions that produce the effects observed. At first, the point will be dipping more rapidly than the trajectory; but as the resistance of the air diminishes and the point comes closer to the trajectory, by virtue of the forward motion of the shot in the direction of the axis and the inward motion of the point due to the resistance of the air acting above the head, the dip will be less, and so the point does not get round below the trajectory at all. It will be observed that the first gyration is small, and if we suppose it to occupy the time the shot would take to range 2200 yds., the effect will be that the axis of the shot will coincide pretty closely with the trajectory for that distance. The second gyration is shown larger, because the resistance of the air has then become less, and the gyration will be made under a greater exposure of surface. This second gyration is therefore what we should have as the first gyration if we were to increase the spin; for the greater stability the shot would have would cause it to wait until a greater amount of surface had been exposed before it would gyrate. It is important to notice

this, because greater spin thus involves greater deflection of axis, and consequently greater resistance of the air; and that this reasoning is sound, is proved by the fact that guns with a rapid twist, if they are accurate shooting guns, and do not deflect at one time to the right and at another to the left, as did the Lancaster gun, always deflect more to the right than those with a less twist.*

These principles have been dwelt on at some length, because it is necessary to know exactly what we have got to do in rifling guns. It is a mistake to suppose that giving a very great twist is all that is required. What is required is to limit the extent of the gyrations as much as possible, so as to keep the point as close as may be to the trajectory, and thus occasion less resistance of the air during the whole flight of the projectile, and the greatest penetration at any point; and what is of still greater importance, to ensure that the gyrations, whatever they may be, shall be regular, so that they may be allowed for and we may have accurate shooting. This last can only be obtained by proper centring; for if the projectile be not properly centred, there is always an initial cause to interfere with the after regularity of the deflection. There can be no doubt, however, that a rapid twist is the best thing that will compensate for want of centring; because, in the first place, it is not so easy to deflect the point of the shot as it comes out of the gun when the twist is great; and, in the second place, any initial deflection which may exist becomes more readily absorbed in the larger and more stable gyration which afterwards ensues. It is better, however, to do with a less rapid twist and more perfect centring, not only because it strains the gun and the projectile less, but also because it in reality gives more accurate shooting.

No one will doubt the fact that some rifled guns shoot better than others, though some may be disposed to question whether the better shooting is due to more perfect centring. The results given in "Reports of Experiments with the Bashforth Chronograph" to determine the resistance of the air, may be therefore stated, in further support of the view here advocated. This instrument gives a very accurate measurement of the resistance of the air, both with round

* The following table, taken from "Reports of Experiments with the Bashforth Chronograph," (p. 168), shows the co-efficients of the resistance of the air with Whitworth and service projectiles:—

Velocity.	Whitworth flat-headed shot.	Ogival radius $= 1\frac{1}{2}$ diameter.	Hemispherical head.	Spherical shot.
f.s. 1140	·0001396	·0001079	·0001329	·0001534
1060	·0001246	·0000972	—	·0001473
928	·0001384	·0000659	—	·0001385

This shows that, with Whitworth shot, the co-efficient of resistance does not decrease with the velocity of translation in the same manner as service rifled and spherical shot; and no doubt the greater spin with Whitworth shot is the cause of this, as explained in the text.

shot and rifled projectiles. With rifled projectiles, the resistances are found to vary to a much greater extent than with round shot; and it is reasonable to suppose that where the resistance of the air is least, the projectiles are centred best, and less perfectly when the resistance of the air is greatest. Great differences are found in this respect; and it is a rule that when the resistance of the air is great, the accuracy is not so good, and *vice versâ*. One gun—a long B.L. 40-pr. converted into a M.L. 47-pr.—is remarkable both for the small amount of resistance it gives, and for its great accuracy of fire. No difficulty is found in firing through ten screens with it without mishap, and it can be fired with accuracy at lower velocities than any of the other guns. The regularity of the resistance of the air is also very remarkable, as compared with the other guns.

If the shot came out of the gun without any deflection of the axis, but rotating round an axis inclined to the longest axis, it would be sufficient to account for the increased resistance of the air. For many reasons it cannot be supposed that this is ever the case. It will not account for the generally inferior shooting which is found with increased resistance, and it is difficult to see how the small amount of play the projectile has in the bore of the gun can be sufficient to account for the great differences in resistance which are found to exist—sometimes as much as 25 or 30 per cent., or even more.

The question arises, how can we suppose a sufficient amount of initial deflection to account for so great an amount of increased resistance? But it will be admitted that there are various causes which will account for this. If the shot be knocking itself against the bore as it moves on, it may have a final knock as it leaves the gun which will have the effect of deflecting the axis sufficiently to account for the differences observed. It is possible that such a knock might be sufficient to upset the stability of the axis, and cause rotation round an axis inclined to the longest; and some people hold this view, and think that it accounts for a very curious fact which has been observed in the penetration of iron plates. On this supposition, the shot comes out of the gun rotating round an axis inclined to the longest axis; and thus at short ranges the amount of surface presented is greater than at longer ranges, when the shot, by virtue of the stability of its axis, has had time to centre itself.* A suggestion may be offered, however, which would account for this fact without supposing that the stability of the axis is upset. It is this:—At the moment the shot is leaving the gun, we may suppose that it is rubbing along the bottom of the bore, and that the gas is rushing over the base of the shot. As soon as the lower part of the base is unsupported, the effect of the gas pressing downwards will be sufficient to give a considerable initial deflection of the point to the right. At first, therefore, the point of the shot will not be in the best position for penetration; but as it proceeds the point will dip, and will not only con-

* General Mayevski supposes another sort of centring action different from this, and probably the same as that given in the text where the curve of the trajectory interferes with the gyration, and at one point brings about a close coincidence between the axis of the projectile and the trajectory. This is not, however, what is here referred to.

form more to the trajectory, but also to the face of the target, which generally has a slight inclination backwards. It seems that this action of the gas would not be sufficient to upset the stability of the axis; because it is evident to all, from the noise that a rifled shot makes on ricocheting, that the stability of the axis is not upset, but only that the point is very much deflected, which causes the regular roaring noise which is heard, each gyration being distinctly traced by the ear. Now, if the severe blow on striking the ground, which causes so great a deflection of the point, is not sufficient to upset the stability of the axis, it is scarcely probable that the lesser blow of the gas on the base of the shot, which produces a much smaller deflection, would be sufficient to do so.

This view is strictly in accordance with the fact that the best remedy for want of centring is to be found in a long gun. All our longest rifled guns shoot best; and, if what has been stated be correct, it is to be expected that they should do so; for the longer the gun, the less will be the stress of the gas as the shot leaves the muzzle, and the less will be the knocking, if any, against the sides.

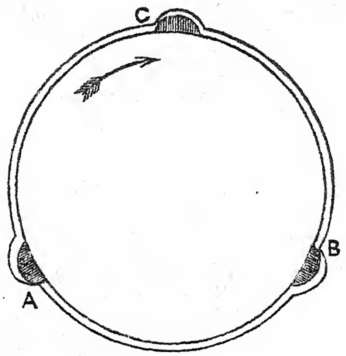
It was found in the Bashforth experiments, that the 9-in. gun gave less resistance of the air when fired with 36 lbs. of R.L.G., than with 43 lbs. This appears to support the idea. Practically, it was found that though 43 lbs. gave 40 ft. more velocity than 36 lbs., yet the latter charge would have a greater striking effect at 2000 yds.

Too much attention has hitherto been given to centring in the bore. What is wanted is, that the projectile shall be centred as it leaves the gun. It may be centred all along the bore, but if it receives a blow from the gas as it leaves the gun, all the advantage will be thrown away. If, by centring in the bore, any knocking against the sides can be mitigated, this will undoubtedly be an advantage. We ought, however, to take a lesson from the results of experience, and it will generally be admitted that to use a long gun is the best method of ensuring accurate centring, and consequently accurate shooting.

A great many methods have been tried, with the view of securing accurate centring. The first, and perhaps the best, was Sir William Armstrong's system of lead-coating. The shot was kept jammed in the bore through its whole length, and could not possibly wabble about. His shunt gun also provided for centring as the shot left the muzzle, by shallowing the grooves just before the shot effected its passage out of the bore. Sir Joseph Whitworth tries to get centring by making his shot as nearly as possible a mechanical fit, with a considerable amount of success. It is probable, however, that his taper base has something to do with the accuracy of shooting he has attained, for it will allow the gas to act more uniformly round the base of the shot as it leaves the gun. This taper base, however, involves a semi-flat head, so as to avoid too great deflection; but the greater resistance of the air which accompanies this is objectionable, and should be avoided if possible.

Another method, which has found many advocates, consists in making the shot centre itself.

It is as follows :—



Suppose a shot, moving along the bore of the gun, is compelled to rotate as shown by the arrow by the bearings at the points *A*, *B*, and *C*, then, by virtue of its inertia, it will assume a position where the rotation is least, and this can only be in the centre of the bore; for it will be observed that if it goes to one side—the bottom, for instance—it can only do so by taking more rotation, pivoting round the point *A*. Rather than do this, it will centre itself in the bore of the gun. Captain Scott, R.N., claims this as an advantage, with his system of rifling, which consists of long iron ribs on the shot, giving a sufficient amount of bearing surface to prevent any wear of the ribs, which would of course interfere with the perfect action of this principle.

The Woolwich system is well known, and practically consists in giving rotation by a single row of soft studs all round the projectile, so as to allow of an increasing twist being given to the grooves of the gun, and thus reduce the maximum strain caused in giving rotation, both on the studs and gun. The small amount of windage given between the shot and the bore, is considered sufficient to give accurate centring. The windage over the studs, also, is less than over the body of the projectile; so that the soft metal studs receive any side blow which may be given to the bore of the gun, and thus diminish any knocking action that may exist.

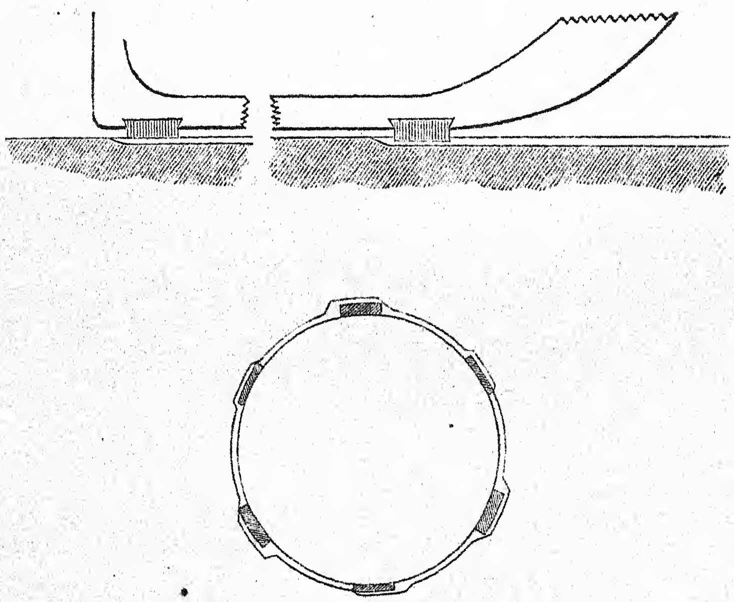
These are all the systems which have been tried in this country which have given results entitling them to be considered applicable to heavy guns; but two others may be mentioned, which have been adopted or tried by foreign Governments, and which are worthy of consideration.

The Austrian Government tried a very long B.L. gun, which fired lead-coated projectiles, but which differed from the Armstrong, not only in the breech-loading action, but also in the grooving of the gun. The number of grooves was reduced to one-half, and the grooves were made very wide, while the lands were very narrow; so that, practically, the lands cut readily into the lead coating, and thus diminished the

friction, while the power to produce rotation was not reduced, but rather increased; for it will be admitted that, as the lead-coating is much softer than the steel land which cuts into it, the strength of the lead-coating will be increased in this manner, while the steel land will have sufficient strength.

The other system is that adopted by the Norwegian Government. It has an uniform twist, and has one row of studs all round the projectile towards the front, to produce rotation, and another towards the base to give centring. These two sets of studs have separate grooves.* The driving grooves are deep, but terminate at some distance from the powder-chamber. The steadying grooves are shallow, and are carried up to the powder-chamber. The studs are not rounded off, but are purposely left angular, so that by the first wear of the driving studs the projectile may come gradually into bearing, and also allow the steadying studs to leave their grooves and jam themselves tightly in the bore of the gun.†

The following wood-cut shows the grooves and studs with their 3-pr. mountain steel gun:—



* In the smaller guns only. In the larger guns the driving and steadying studs are in the same groove, and a similar action is obtained by sloping away the driving edges of the driving-studs.

† Probably some such action as this exists in the Woolwich gun; for it will be observed in the recovered projectiles that, in some cases, nearly one-half of the studs are worn away. Thus one half of each stud may give rotation, and the other half centring.

A great many points of considerable importance must be borne in mind in considering the value of these different systems of rifling. The first, and not the least, is the effects they have on the strength of the gun. Those which cut deep grooves are most detrimental in this respect, and thus far the Austrian experimental gun has an undoubted superiority; for not only are the grooves shallow, but—what is of much more importance—they are many and broad. One groove in the bore of a gun injures the gun much more than fifty; for we must not only provide for the strength, but also for the stretch of the bore. If there be only one groove, the whole stretch tends to come on that part, because it is weakest and yields most readily. It is the same principle which has been successfully avoided by Sir William Palliser, in making the body of his bolts less in diameter than the weakest parts of the thread, so that the stretch comes on the body which is long rather than on the shallow part of the threads, which are comparatively very short. The defect of this law was also discovered and early avoided in the Royal Gun Factories, by not cutting the thread for the breech-screw deeper into the breech-piece than that part which received the steel tube. No other system avoids this objection; for we find they all cut grooves into the bore of the gun, and thus injure it more or less. Even Whitworth's hexagonal system of rifling is a grooved system in this respect.

Those systems which have most grooves are, however, to be preferred to those which have fewer; and the fact that the Norwegian system has a double number of grooves is rather an advantage than a disadvantage.

In connection with the effect any system of rifling has on the strength of the gun, a most material point is the windage given. A very small increase of the amount of powder consumed causes also a very great increment of pressure, and a very small amount of windage gives a corresponding relief. This is a difficult problem, for windage is the main cause of the scoring and destruction of the guns at present in the service. The only escape out of the two objections is to stop the windage over the body, and give it through the interior of the projectile, utilizing it at the same time to ignite the fuze. Lead-coating effectually stops windage, advantageously or disadvantageously; and in this respect is superior or inferior to all other systems, according to the circumstances of the case. It is possible to stop windage in all guns by the use of an expanding wad, which would thus render them all practically equal in this respect.

It remains now to consider the strain and friction on the surface of the projectile, and on the grooves of the gun. The easiest way of doing this is to compare the amount of force required to produce rotation with that to produce translation, and also the friction of the shot along the bore.

Let $x =$ the distance travelled by the shot in the time t,
$\theta =$ the angle of rotation described in the same time,
$P =$ pressure producing translation,
$p =$ " " rotation.

Then, in a cylinder of $r =$ radius and $M =$ mass, for one turn in n calibres,

$$x = nr\frac{\theta}{\pi},$$

$$\frac{d^2x}{dt^2} = \frac{nr}{\pi}\frac{d^2\theta}{dt^2}.$$

But

$$\frac{d^2\theta}{dt^2} = \frac{pr}{M\frac{r^2}{2}} = \frac{2p}{Mr},$$

and

$$\frac{d^2x}{dt^2} = \frac{P}{M};$$

therefore

$$\frac{P}{M} = \frac{nr}{\pi} \times \frac{2p}{Mr},$$

and

$$P = \frac{2np}{\pi}$$
$$= 25p, \text{ if } n = 40.$$

Thus, with an uniform twist of 1 turn in 40 calibres, the force producing rotation at the surface of the shot is 4 per cent. of the total pressure of the gas at any moment on the base of the shot. The useful effect of the force of translation absorbed is, however, the resolved part of this along the bore, or about $\frac{1}{13}$ of 4 per cent.—*i.e.*, $\frac{1}{3}$ per cent. nearly. The friction, however, has to be added to this, which, supposing it to be $\frac{1}{4}$ of the pressure, gives 1 per cent. in addition; thus using altogether $1\frac{1}{3}$ per cent of the force of translation. Thus, with a 600-lb. shot in a 12-in. bore, with 20 tons per square inch of maximum pressure of powder, the pressure producing rotation would be 90 tons; with a 15-in. gun and 1200-lb. shot and 25 tons pressure, it would be 180 tons. If we suppose excessive pressures, such as often occur in the bores, of twice or thrice the amount supposed, these pressures will be doubled or trebled.

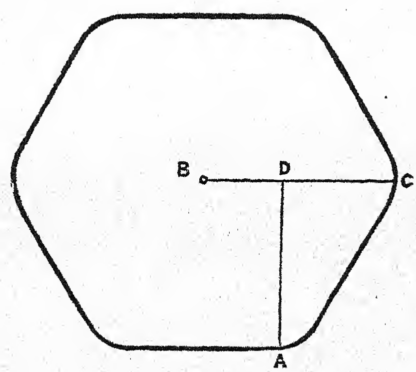
The effect of the increasing twist is to make the amount of pressure depend, not on the amount of maximum pressure of the powder, but on the amount of rotation to be produced, distributing the pressure more uniformly along the whole bore of the gun, and making it less as the length of the gun is increased. With the length in use with our service guns, and with the twist used in the 10-in. gun—from 1 turn in 100 to 1 in 40 calibres—it has been shown by Captain Noble,* late R.A., now of Elswick, that the pressure is uniformly distributed, with the pressures found by the Committee of Explosives to exist in that gun, and does not exceed half of what it would be if the twist were uniform. If,

* "On the Pressure required to give Rotation to Rifled Projectiles," by Captain Noble, F.R.S., &c., late R.A. "Proceedings, R.A. Institution," Vol. VIII. p. 359.

however, the initial pressure in the bore were doubled or trebled, there would also be a maximum pressure double or treble the amount calculated.* The twist increasing from 0 to 1 in 40 would have the effect of giving a greater pressure towards the muzzle of the gun than one from 1 in 100 to 1 in 40; but it would have the advantage of having no maximum pressure at the commencement of motion, when the initial pressure on the base of the shot was doubled or trebled. The practical result, therefore, of a spiral increasing from 0 is that with a good uniform powder the maximum pressure is about $\frac{2}{3}$ that with an uniform twist; but with a maximum pressure of twice or thrice the legitimate pressure in the powder-chamber, it will be reduced to $\frac{1}{3}$ or $\frac{2}{9}$ of what an uniform twist would give under similar circumstances.

In order, therefore, to provide against all possible contingencies, an uniform twist ought to have four times the strength of studs or ribs to be as safe as one increasing from 0 to the same amount of twist with guns of the service length. If, therefore, an uniform twist has four times the bearing surface of an increasing twist, it is practically as safe. Comparing Captain Scott's system with the Woolwich on this subject, it will be seen that it is quite as safe, and indeed very much safer, for it has much more than four times the bearing surface.

The shunt system has nearly—perhaps not quite—four times the bearing surface, and no doubt would be quite strong enough. The Whitworth gun has much more than four times the bearing surface. The pressure which produces rotation, however, by no means acts at the extremity of the radius of the projectile, but at between $\frac{1}{2}$ and $\frac{1}{3}$ that distance, as will be observed by the accompanying woodcut, where the pressure at *A*—the driving edge of the groove—acting normally to the surfaces, has a direction *AD*, which practically makes *BD* less than one-half the radius *BC*.



* Captain Noble takes no account of these very high pressures in his calculation. They ought not, however, to be omitted in the consideration of the proper rifling of our heaviest guns, in which they are found to a very great extent. It is because they exist that the increasing twist from 0 to 1 in 40 is superior to one from 1 in 100 to 1 in 40; and no doubt it is for this reason that the latter twist has been abandoned in favour of the former. The 10-in. gun has a twist from 1 in 100 to 1 in 40, and it will be observed that projectiles fired from this gun have the studs very much worn. It is worthy of remark, that both the 10-in. and 35-ton guns shoot remarkably well; the latter gun has a twist commencing from 0.

Taking a 600-pr. gun and high pressures, we should, under the same conditions as before, have with the Whitworth rifling about 700 tons producing rotation, which would be more than 100 tons on each edge; and if we suppose the driving edge to be 1 in. wide* and 20 ins. long, it would, with 1 turn in 40 calibres, give a pressure of 5 tons per square inch, which, on the great amount of surface employed, must produce enormous friction. With a 1200-pr. it would be worse and worse—about 8 tons per square inch on a still greater surface. Still worse, however, Whitworth's small bore necessitates a twist of 1 turn in 20 calibres; so that these pressures, great as they are, would have to be doubled. It is difficult to estimate the amount of longitudinal pressure that would thus be consumed; the co-efficient of friction with such high pressures being very great. Probably it would not be less than 10 per cent.

Captain Scott's system, having less bearing surface, but acting at the end of the radius, will probably, with the same twist and number of grooves,† have about the same amount of pressure per square inch as Whitworth's system, but will impede the velocity of the projectile less, owing to the smaller amount of surface under friction. The number of his grooves, however, can be increased to any amount, and thus the friction can be reduced to any extent desirable—a point of very great importance, as there is a limit, by the laws of practical mechanics, to the amount of pressure which should be given between surfaces in contact—700 lbs. per square inch.

With lead-coated projectiles, the whole surface would probably be under the action of friction to produce rotation; but, owing to the softness of the lead, and the difficulty of securing its proper adhesion to the body of the shot, it is hard to form any estimate of its value with very heavy guns. The longitudinal friction of the lead-coating in the bore is enormous, wasting on an average, with very heavy guns, about 10 per cent. of the useful effect of the gas—no other system, except Whitworth's, wasting nearly the same amount of the longitudinal pressure forward.

The Norwegian system is less capable of giving effective rotation. The number of the driving studs could, however, easily be increased. But, instead of this, the rotation is diminished, giving only 1 turn in 55 calibres; and with large bores and tolerable centring very good shooting is obtained.

Excepting, perhaps, lead-coated projectiles, the Woolwich studs are strained most severely, and are often subjected to a strain of probably 20 tons per square inch, causing the studs to bulge. An extra stud,

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* Whitworth claims a greater breadth of bearing surface than is here stated, but it is questionable if he gets more; because the pressure is obtained by the yielding of the metal to some extent, and this can scarcely be allowed for. Besides, any additional surface brought into play will act at shorter radius, and produce less proportionate effect in giving rotation, but more in giving friction.

† The grooves, however, are here supposed to be deeper than those used by Captain Scott in his guns of smaller calibre, which are only ·125 in. deep. It is not necessary to consider the depth of Captain Scott's grooves an essential element of his system, any more than the number. As the number increases, so may the depth without detriment. Whitworth, however, cannot increase the number of his grooves.

however, has been inserted in each longitudinal row, which materially increases the strength. The studs are often very much worn by the great friction, which must necessarily cause a greater waste of longitudinal pressure than if so much wear did not take place, as well as try severely the driving edge of the grooves.

Nothing has been said on the relative merits as regards centring of these systems of rifling, because little is known. The best way of testing them on this point would be to fire through a number of paper screens at different distances, so as to trace the trajectory, using at the same time the Bashforth chronograph to obtain the resistance of the air. The latter would give the amount of deflection of the point of the projectile, and the former the direction of the deflection.

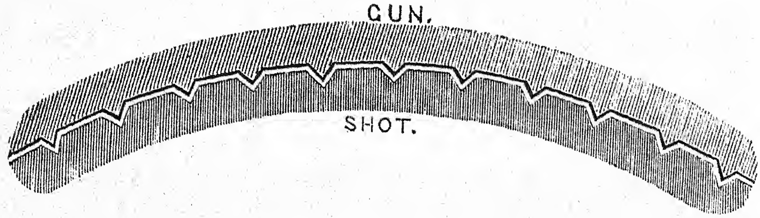
These considerations would appear to show that the palm of undoubted superiority cannot be given to any one system over all the others; each has its advantages and its disadvantages, and none are without objections. This is generally admitted, and has come to be thought unavoidable in all rifling. That such, however, is not necessarily the case, is a consideration which the following proposal is intended to show.

It may be briefly stated thus:—Adopt the system of grooving in the Austrian B.L. experimental gun, but do not adopt the lead-coated projectiles. The lead-coated projectiles, in addition to the disadvantages pointed out, have the serious disadvantage mentioned by Colonel Reilly, R.A.,* of being less effective against armour plates than iron projectiles, because the lead flies off on impact and does not help the projectile through the target. But if we groove the projectiles so as to fit the projecting ribs of the gun, we do away with this objection, and we get an amount of bearing surface which alone meets the mechanical requirements of the case. With 64 grooves in the shot, and the same number of lands in the gun, each ·3 in. deep, we have an amount of bearing surface which, under ordinary pressures, in a 15-in. gun, with a projectile of 1200 lbs., and a twist of one turn in 40 calibres, would reduce the pressure below 700 lbs.† per square inch—the mechanical limit of pressure between surfaces in contact under friction. Here, then, is a perfect system of giving rotation. It does not cut into the bore of the gun, and therefore does not weaken it; and it will not wear the grooves, nor waste more than probably one-half of a per cent. of the longitudinal pressure of the gas, because with the small amount

* "Notes of a visit to Berlin, December, 1872," by Lieutenant-Colonel E. Reilly, C.B., Assistant Director of Artillery, page 20:—"This lead covering causes a great waste of power, as it is the iron part alone of the shell that can do work against the iron plates, and consequently a considerable force is expended in projecting a part of the projectile which is useless for the work which has to be performed." On this point Mr. Krupp remarks (letter 16th February, 1870), that the experiments at Tegel, 4th August, 1868, "again demonstrate that, in the case of the breech-loading projectiles, a heavy lead-coating can so weaken the effect as to render it insufficient." And Captain von Doppelmair—a strong advocate of Mr. Krupp—says: "We shall not be much in error when calculating the momentum of a lead-coated shot if we only take into account the weights of the cast-iron or steel core" (pamphlet).

† This is for ordinary pressures. With exceptional pressures, the same as in the other calculations, the maximum would be about one ton per square inch.

of pressure between the ribs and grooves, lubrication may be used. Practically, so far as rifling is concerned, both gun and projectile are everlasting.



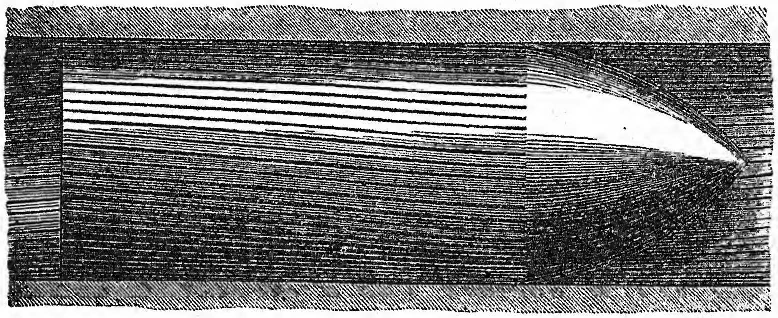
The following table will serve for comparison of the probable pressures which produce rotation, and are wasted in friction, with the various systems of rifling. They are all calculated for a twist of one turn in 40 calibres, so that those given with Whitworth's rifling would have to be doubled for one turn in 20 calibres adopted by him. The pressures in *italics* are those due to exceptionally high pressures.

Systems of rifling.	600-pr. gun.				1200-pr. gun.			
	Bearing surface inches.	Pressure on studs. Total tons.	Pressure on studs. Per sq. in. tons.	Longitudinal pressure wasted per cent.	Bearing surface inches.	Pressure on studs. Total tons.	Pressure on studs. Per sq. in. tons.	Longitudinal pressure wasted per cent.
Woolwich. uniform twist....	5	90	18	$1\frac{1}{2}$	7	180	26	$1\frac{3}{4}$
"	*5*	*225*	*45*	*2*	*7*	*450*	*65*	*2*
1 in 100 to 1 in 40	3	45	15	$1\frac{1}{2}$	4	90	23	$1\frac{3}{4}$
"	*3*	*111*	*37*	*2*	*4*	*225*	*58*	*2*
0 to 1 in 40	3	60	20	$1\frac{1}{2}$	4	120	30	$1\frac{3}{4}$
"	*3*	*60*	*20*	*$1\frac{1}{2}$*	*4*	*120*	*30*	*$1\frac{3}{4}$*
Whitworth hexagonal	120	240	2	4	170	480	3	$4\frac{1}{2}$
"	*120*	*600*	*5*	*5*	*170*	*1200*	*$7\frac{1}{2}$*	*$5\frac{1}{2}$*
Scott	45	90	2	$1\frac{1}{3}$	60	180	3	$1\frac{1}{2}$
"	*45*	*225*	*5*	*$1\frac{1}{2}$*	*60*	*450*	*$7\frac{1}{2}$*	*2*
Lead-coating	—	—	—	10	—	—	—	10
"	—	—	—	—	—	—	—	—
Proposed rifling ...	240	90	$\frac{1}{3}$	$\frac{1}{2}$	540	180	$\frac{1}{3}$	$\frac{1}{2}$
" ...	*240*	*225*	*$\frac{5}{6}$*	*1*	*540*	*450*	*1*	*1*

There are some other points which may be considered more in detail. It may be thought that the expense of cutting so great a number of grooves in each shot will be considerable; but in the opinion of a very able practical engineer and mechanic,* this would not be the case, for a

* On this point, Dr. Anderson, Superintendent of Machinery, War Department, observes in a letter to the writer, 12th May, 1873, "If the projectiles were to be done in large numbers, so as to make it worth while to provide self-acting tools to act with a number of cutting instruments simultaneously, the cost for wages would be very trifling, requiring one quarter of an hour of unskilled labour. Of course, the size would have an influence, but the cost would not be any barrier to the system if it is right in other respects."

machine could easily be constructed which would cut them all in one operation.



But how about chilled projectiles? They can be turned and grooved, though it is more expensive to do so than with ordinary cast-iron. It would be better, however, to cast the shot in a cylinder of cast or wrought-iron, and groove the outer casing thus formed. A wrought-iron casing would be a very great advantage; because on striking an iron plate the tendency of the body of the shot is to split in two and fly forward like lead-coating, while the head jams in between the two pieces, but a wrought-iron casing would prevent this.*

Another great advantage is that it could be used with breech-loading as well as with muzzle-loading guns. It is by no means an easy problem to solve how we are to secure that the projectile shall occupy its proper seat if we do away with lead-coating; because any arrangements made when the gun was new might fail if the bore was worn out by scoring. It would be very easy to stop the scoring on this plan by a wad; for the sharp edges of the ribs would readily cut into the wad and preserve the bore, or at all events the ribs themselves, from being eaten away. All that would have to be done would therefore be to insert small zinc studs in a few of the grooves, and allow the projectile to go up until these studs come to where the ribs terminate beyond the powder-chamber. These zinc studs would probably afterwards aid the centring. The bore would thus not only not be weakened, as in nearly every other system, by narrow deep grooves cut in the most vital part of the gun, but would not wear out by scoring; and if combined with the gun brought forward by the writer in this Institution nearly four years ago,† the endurance of our heaviest guns would probably be extended to

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* Captain C. Orde Browne, late R.A., and Captain Instructor Royal Laboratory, in "Proceedings, Royal Artillery Institution," Vol. VII. page 25, says:—"The projectiles cast with sand bodies are superior in penetration to those entirely chilled; because, as may be seen, while the pressure round the head towards a centre does not test its tenacity, the base is in a very different condition. The metal then having lent its force to some extent to the head, shivers away to the front, generally indenting the plate round the hole made by the head. Any increase of tenacity in the material at the base is therefore clearly an advantage."

† See "Proceedings, Royal Artillery Institution," Vol. VII. pp. 145 and 436.

10,000 or 20,000 rounds. The use of a wad would not only stop the scoring, but might also materially improve the accuracy of practice, if it prevented any rush of gas over the base of the projectile to produce initial deflection as the shot left the gun. With a breech-loading gun the windage might be much reduced, and in all probability the shot would come out perfectly centred; for whatever advantage is to be gained by the principle of centring is to be found in this gun. And not this only, but the fact that length in the gun is the only sure method of obtaining accurate practice could be taken advantage of; for with a breech-loading gun there is no limit to the length of the gun which can be made.

COPY OF A MEMORANDUM ON THE USE OF SHEEP EMPLOYED TO CARRY LOADS ACROSS THE KARAKORUM,

BY CAPTAIN BIDDULPH, 19th HUSSARS.

COMMUNICATED BY

CAPTAIN E. F. CHAPMAN, R.A.

SECRETARY YARKUND MISSION.

[The facts recorded will explain the nature of the journey undertaken by that portion of the Yarkund Mission which has just crossed by the Changchemno route.]

Copy of Memorandum on the use of Sheep loaded with Supplies crossing the Karakorum.

CAMP, SHAHIDULLA,
October 19, 1873.

I left Thansie on September 18, taking with me 30 sheep, carrying loads of grain and attah. Wishing merely to test their marching capabilities, I looked upon the supplies they carried as extra, and their loads remained intact till within four marches of Shahidulla, when I was forced to commence using them.

The Tartars usually make them carry a load of 32 lbs., and march 7 or 8 miles a day only; as, however, I knew I should be marching hard at times, I put only a load of 20 lbs. on each sheep. Beyond this I took no care of them, and they simply took their chance.

The accompanying table will show the particulars of the marches they made. I was accompanied the whole time by a Survey Pundit, who paced the distance each day.

A great part of the route was over rough and stony ground; but only one sheep broke down, though many of them showed signs of footsoreness at times. The loads, secured by breast and breech ropes, ride well, sinking into the fleece, and not being liable to shift.

One man was sufficient to manage the lot; and two men, I should say, could easily drive and manage a hundred. On fair ground, where they travel with a broad front, they marched at the rate of $1\frac{3}{4}$ miles

an hour. A large number would no doubt travel slower, and much must depend on the breadth of the road.

The greatest difficulty they had to contend with was crossing streams; and marching so much in the Karakash Valley, they were sometimes obliged to cross the river three or four times a day. Not only were their loads liable to become damaged, but the weight of water hanging in their fleeces, and on several occasions freezing, greatly impeded progress.

On the days on which they had no grass, they had literally nothing to eat; as they refused grain, not being accustomed to it.

On arrival at camp, they were unloaded and turned out to shift for themselves till dark, when they were herded for the night.

(Signed),

JOHN BIDDULPH, Captain,

A.D.C. to H.E. the Viceroy,

Yarkund Embassy.

To

Lieut.-Colonel Gordon,

Yarkund Embassy.

Table showing marches taken by a Flock of 30 *Sheep, carrying loads of* 20 *lbs.*

March.	Date.	Miles.	Remarks.
	1873.		
Thansie to Ichur-Ka-talab	Sept. 18	14	
Luhung	" 19	$7\frac{1}{4}$	
Chagra	" 21	8	
Rimdi	" 22	13	Crossed Lunhur La, 18,400 ft.
Pamzal	" 23	13	
Gogra	" 24	$12\frac{1}{2}$	
Shummal Lungpa	" 26	12	
Camp near Nischu	" 27	$14\frac{1}{4}$	No grass. Crossed Changlung La, 1,280 ft.
Do. on Lingzi Thung	" 28	$16\frac{1}{2}$	No grass.
Camp	" 29	$20\frac{1}{2}$	No grass.
Sumna	" 30	$21\frac{1}{2}$	Crossed Kizzil Dawan, 17,600 ft. Did not arrive in camp till dark.
Kizzil Jilga	Oct. 1	11	
Chung Tash	" 7	24	Grass very scarce. Did not arrive till after dark.
Sumnal	" 9	13	
Camp	" 10	$10\frac{1}{4}$	Grass very scarce.
Do.	" 11	15	No grass.
Do.	" 12	$16\frac{3}{4}$	No grass. One sheep broke down on march.
Sorah	" 13	$5\frac{1}{2}$	
Camp	" 14	13	
Do.	" 15	18	Supplies not used till this evening.
Do.	" 16	$10\frac{1}{2}$	
Gulbasher	" 17	18	
Shahidulla	" 18	23	Total, $330\frac{1}{2}$ miles. The last eleven marches down the Valley of the Karakash.

PROBABLE RECTANGLES.

BY

CAPTAIN W. H. NOBLE, R.A.

This method of comparing the shooting of different guns was proposed by Captain A. Noble, F.R.S., late R.A. It is fully described in the "Occasional Papers of the Royal Artillery Institution," Vol. I. p. 173.

The "probable rectangle" represents an area on the horizontal plane, within which there is an even chance of any one shot falling; that is to say, the area would probably contain half the number of shots fired. The smaller the rectangle, therefore, the greater the accuracy of the shooting. The length of the probable rectangle depends upon the value of the "mean difference of range;" the breadth upon that of the "mean reduced deflection," or—

$$\text{Length} = \frac{\text{sum of differences of range from mean range}}{\text{one less than the number of shots}} \times \text{constant.}$$

$$\text{Breadth} = \frac{\text{sum of differences of deflection from mean deflection}}{\text{one less than the number of shots}} \times \text{constant.}$$

The mean difference of range* and mean difference of deflection*—or mean *reduced* deflection, as it is usually called—are given in all abstracts of practice; and a table has been computed to facilitate the calculation of the corresponding dimensions of the rectangle. It comprises values from 0 to 100, and is calculated to two places of decimals. For example, the following, taken from p. 22 of the Report of the Special Committee on Field Artillery Equipment for India, gives an abstract of the shooting of the 9-pr. rifled M.L. gun with shell of 9 lbs. and charge of $1\frac{3}{4}$ lb.:—

Number of shots.	Elevation.	Mean range.	Mean difference of range.	Mean reduced deflection.	Length and breadth of corresponding probable rectangle direct from table.	
					Length.	Breadth.
	°	yds.	yds.	yds.	yds.	yds.
10	1	763	15·0	0·4	46·68	1·05
10	2	1176	14·2	0·5	41·67	1·58
10	3	1552	17·1	0·8	50·11	2·37

* Sometimes called mean *error* of range and mean *error* of deflection.

Let us take the practice at 1°. As there were 10 rounds fired, the sum of the differences of range will be 15·9 multiplied by 10 = 159, and the sum of the mean differences of deflection 0·4 multiplied by 10 = 4.

These respective figures must be divided by one less than the number of shots.

$$\rho = \frac{159}{9} = 17{\cdot}67,$$

$$\delta = \frac{4}{9} = 0{\cdot}44.$$

But for all ordinary comparisons we may discard the second place of decimals, and take

$$\frac{159}{9} = 17{\cdot}7,$$

$$\frac{4}{9} = 0{\cdot}4.$$

The length of the probable rectangle is then found from the table by taking the number corresponding to 17·7. The left-hand column gives 17, and, running the finger along the horizontal line, the number 46·68 will be found under ·7 in the top column; 46·68 yds. is therefore the length of the probable rectangle. Similarly, 1·05 yds., corresponding to 0·4, is the breadth of the probable rectangle.

But if it be wished to work with greater accuracy—that is, to a second or third place of decimals—it is easy to do so by proportional parts. Thus, let the numbers be as at first calculated—17·67 and 0·44. The value for 17·6 = 46·42, and the value for 17·7 = 46·68; it is evident, therefore, that the value for 17·67 lies somewhere between 46·42 and 46·68. The difference between the two latter numbers is ·26, and the proportional part to be added to the decimal part of 46·42 will be found by multiplying this by ·07 and dividing it by ·10; or, in round numbers, by multiplying 26 by 7 and dividing by 10.

$$\frac{26 \times 7}{10} = \frac{182}{10} = 18,$$

and

$$\begin{array}{r} 46{\cdot}42 \\ {\cdot}18 \\ \hline 46{\cdot}60 \end{array}$$

Similarly, the value for 0·44 lies somewhere between the values for 0·4 and 0·5—that is, between 1·05 and 1·32. The difference between the latter is ·27, and the proportional part will be

$$\frac{27 \times 4}{10} = \frac{108}{10} = 11,$$

and

$$\begin{array}{r} 1{\cdot}05 \\ {\cdot}11 \\ \hline 1{\cdot}16 \end{array}$$

Therefore the length and breadth of the probable rectangle will be 46·60 yds. and 1·16 yds.

There is no practical difference between these dimensions and those found direct from the table, by working only to one place of decimals.

Table of Dimensions of Probable Rectangles.

Value of ρ and δ.	Dimensions of Rectangle.									
	·0	·1	·2	·3	·4	·5	·6	·7	·8	·9
0	0·00	0·26	0·53	0·79	1·05	1·32	1·58	1·85	2·11	2·37
1	2·64	2·90	3·16	3·43	3·69	3·95	4·22	4·48	4·74	5·01
2	5·27	5·54	5·80	6·06	6·33	6·59	6·85	7·12	7·38	7·64
3	7·91	8·17	8·44	8·70	8·96	9·23	9·49	9·75	10·02	10·28
4	10·54	10·81	11·07	11·33	11·60	11·86	12·13	12·39	12·65	12·92
5	13·18	13·44	13·71	13·97	14·24	14·50	14·76	15·03	15·29	15·55
6	15·82	16·08	16·35	16·61	16·87	17·14	17·40	17·66	17·93	18·19
7	18·46	18·72	18·98	19·25	19·51	19·78	20·04	20·30	20·57	20·83
8	21·09	21·36	21·62	21·89	22·15	22·41	22·68	22·94	23·20	23·47
9	23·73	24·00	24·26	24·52	24·79	25·05	25·31	25·58	25·84	26·11
10	26·37	26·63	26·90	27·16	27·43	27·69	27·95	28·22	28·48	28·74
11	29·01	29·27	29·54	29·80	30·06	30·33	30·59	30·85	31·12	31·38
12	31·65	31·91	32·17	32·44	32·70	32·97	33·23	33·49	33·76	34·02
13	34·28	34·55	34·81	35·08	35·34	35·60	35·87	36·13	36·39	36·66
14	36·92	37·19	37·45	37·71	37·98	38·24	38·50	38·77	39·03	39·30
15	39·56	39·82	40·09	40·35	40·62	40·88	41·14	41·41	41·67	41·93
16	42·20	42·46	42·73	42·99	43·25	43·52	43·78	44·04	44·31	44·57
17	44·84	45·10	45·36	45·63	45·89	46·16	46·42	46·68	46·95	47·21
18	47·47	47·74	48·00	48·27	48·53	48·80	49·06	49·32	49·58	49·85
19	50·11	50·38	50·64	50·90	51·17	51·43	51·69	51·96	52·22	52·49
20	52·75	53·01	53·28	53·54	53·80	54·07	54·33	54·60	54·86	55·12
21	55·39	55·65	55·91	56·18	56·44	56·70	56·97	57·23	57·49	57·76
22	58·02	58·29	58·55	58·81	59·08	59·34	59·60	59·87	60·13	60·39
23	60·66	60·92	61·19	61·45	61·71	61·98	62·24	62·50	62·77	63·03
24	63·29	63·56	63·82	64·08	64·35	64·61	64·88	65·14	65·40	65·67
25	65·93	66·19	66·46	66·72	66·98	67·25	67·51	67·78	68·04	68·30
26	68·57	68·84	69·10	69·36	69·62	69·89	70·15	70·41	70·68	70·94
27	71·21	71·47	71·73	72·00	72·26	72·53	72·79	73·05	73·32	73·58
28	73·84	74·11	74·37	74·64	74·90	75·16	75·43	75·69	75·95	76·22
29	76·48	76·75	77·01	77·27	77·54	77·80	78·06	78·33	78·59	78·86
30	79·12	79·38	79·65	79·91	80·18	80·44	80·70	80·97	81·23	81·49
31	81·76	82·02	82·29	82·55	82·81	83·08	83·34	83·60	83·87	84·13
32	84·40	84·66	84·92	85·19	85·45	85·72	85·98	86·24	86·51	86·77
33	87·03	87·30	87·56	87·83	88·09	88·35	88·62	88·88	89·14	89·41
34	89·67	89·94	90·20	90·46	90·73	90·99	91·25	91·52	91·78	92·05

Table of Dimensions of Probable Rectangles.—(*Continued*).

Value of ρ and δ.	Dimensions of Rectangle.									
	·0	·1	·2	·3	·4	·5	·6	·7	·8	·9
35	92·31	92·57	92·84	93·10	93·37	93·63	93·89	94·16	94·42	94·68
36	94·95	95·21	95·48	95·74	96·00	96·27	96·53	96·79	97·06	97·32
37	97·59	97·85	98·11	98·38	98·64	98·91	99·17	99·43	99·70	99·96
38	100·22	100·49	100·75	101·02	101·28	101·54	101·81	102·07	102·33	102·60
39	102·86	103·13	103·39	103·65	103·92	104·18	104·44	104·71	104·97	105·24
40	105·50	105·76	106·03	106·29	106·55	106·82	107·08	107·35	107·61	107·87
41	108·14	108·40	108·66	108·93	109·19	109·45	109·72	109·98	110·24	110·51
42	110·77	111·04	111·30	111·56	111·83	112·09	112·35	112·62	112·88	113·14
43	113·41	113·67	113·94	114·20	114·46	114·73	114·99	115·25	115·52	115·78
44	116·04	116·31	116·57	116·83	117·10	117·36	117·63	117·89	118·15	118·42
45	118·68	118·94	119·21	119·47	119·74	120·00	120·26	120·53	120·79	121·05
46	121·32	121·58	121·85	122·11	122·37	122·64	122·90	123·16	123·43	123·69
47	123·96	124·22	124·48	124·75	125·01	125·28	125·54	125·80	126·07	126·33
48	126·59	126·86	127·12	127·39	127·65	127·91	128·18	128·44	128·70	128·97
49	129·23	129·50	129·76	130·02	130·29	130·55	130·81	131·08	131·34	131·61
50	131·87	132·13	132·40	132·66	132·92	133·19	133·45	133·72	133·98	134·24
51	134·51	134·77	135·03	135·30	135·56	135·82	136·09	136·35	136·61	136·88
52	137·14	137·41	137·67	137·93	138·20	138·46	138·72	138·99	139·25	139·51
53	139·78	140·04	140·31	140·57	140·83	141·10	141·36	141·62	141·89	142·15
54	142·41	142·68	142·94	143·20	143·47	143·73	144·00	144·26	144·52	144·77
55	145·05	145·31	145·58	145·84	146·11	146·37	146·63	146·90	147·16	147·42
56	147·69	147·95	148·22	148·48	148·74	149·01	149·27	149·53	149·80	150·06
57	150·33	150·59	150·85	151·12	151·38	151·65	151·91	152·17	152·44	152·70
58	152·96	153·23	153·49	153·76	154·02	154·28	154·55	154·81	155·07	155·34
59	155·60	155·87	156·13	156·39	156·66	156·92	157·18	157·45	157·71	157·98
60	158·24	158·50	158·77	159·03	159·29	159·56	159·82	160·09	160·35	160·61
61	160·88	161·14	161·40	161·67	161·93	162·19	162·46	162·72	162·98	163·25
62	163·51	163·78	164·04	164·30	164·57	164·83	165·09	165·36	165·62	165·88
63	166·15	166·41	166·68	166·94	167·20	167·47	167·73	168·09	168·26	168·52
64	168·78	169·05	169·31	169·57	169·84	170·10	170·37	170·63	170·89	171·16
65	171·42	171·68	171·95	172·21	172·48	172·74	173·00	173·27	173·53	173·79
66	174·06	174·32	174·59	174·85	175·11	175·38	175·64	175·90	176·17	176·43
67	176·70	176·96	177·22	177·49	177·75	178·02	178·28	178·54	178·81	179·07
68	179·33	179·60	179·86	180·13	180·39	180·65	180·92	181·18	181·44	181·71
69	181·97	182·24	182·50	182·76	183·03	183·29	183·55	183·82	184·08	184·35
70	184·61	184·87	185·14	185·40	185·67	185·93	186·19	186·46	186·72	186·98
71	187·25	187·51	187·78	188·04	188·30	188·57	188·83	189·09	189·36	189·62
72	189·89	190·15	190·41	190·68	190·94	191·21	191·47	191·73	192·00	192·26
73	192·52	192·79	193·05	193·32	193·58	193·84	194·11	194·37	194·63	194·90
74	195·16	195·43	195·69	195·95	196·22	196·48	196·74	197·01	197·27	197·54
75	197·80	198·06	198·33	198·59	198·85	199·12	199·38	199·65	199·91	200·17
76	200·44	200·70	200·96	201·23	201·49	201·75	202·02	202·28	202·54	202·81
77	203·07	203·34	203·60	203·86	204·13	204·39	204·65	204·92	205·18	205·44

TABLE OF DIMENSIONS OF PROBABLE RECTANGLES.—(*Continued*).

Value of ρ and δ.	Dimensions of Rectangle.									
	·0	·1	·2	·3	·4	·5	·6	·7	·8	·9
78	205·71	205·97	206·24	206·50	206·76	207·03	207·29	207·55	207·82	208·08
79	208·34	208·61	208·87	209·14	209·40	209·66	209·93	210·19	210·45	210·72
80	210·98	211·24	211·51	211·77	212·04	212·30	212·56	212·83	213·09	213·35
81	213·62	213·88	214·15	214·41	214·67	214·94	215·20	215·46	215·73	215·99
82	216·26	216·52	216·78	217·05	217·31	217·58	217·84	218·10	218·37	218·63
83	218·89	219·16	219·42	219·69	219·95	220·21	220·48	220·74	221·00	221·27
84	221·53	221·80	222·06	222·32	222·59	222·85	223·11	223·38	223·64	223·91
85	224·17	224·43	224·70	224·96	225·23	225·49	225·75	226·02	226·28	226·54
86	226·81	227·07	227·34	227·60	227·86	228·13	228·39	228·65	228·92	229·18
87	229·45	229·71	229·97	230·24	230·50	230·77	231·03	231·29	231·56	231·82
88	232·08	232·35	232·61	232·88	233·14	233·40	233·67	233·93	234·19	234·46
89	234·72	234·99	235·25	235·51	235·78	236·04	236·30	236·57	236·83	237·10
90	237·36	237·62	237·89	238·15	238·41	238·68	238·94	239·21	239·47	239·73
91	240·00	240·26	240·52	240·79	241·05	241·31	241·58	241·84	242·10	242·37
92	242·63	242·90	243·16	243·42	243·69	243·95	244·21	244·48	244·74	245·00
93	245·27	245·53	245·80	246·06	246·32	246·59	246·85	247·11	247·38	247·64
94	247·90	248·17	248·43	248·69	248·96	249·22	249·49	249·75	250·01	250·28
95	250·54	250·80	251·07	251·33	251·60	251·86	252·12	252·39	252·65	252·91
96	253·18	253·44	253·71	253·97	254·23	254·50	254·76	255·02	255·29	255·55
97	255·82	256·08	256·34	256·61	256·87	257·14	257·40	257·66	257·93	258·19
98	258·45	258·72	258·98	259·25	259·51	259·77	260·04	260·30	260·56	260·83
99	261·09	261·36	261·62	261·88	262·15	262·41	262·67	262·94	263·20	263·47
100	263·73	263·99	264·26	264·52	264·79	265·05	265·31	265·58	265·84	266·10

October 22, 1873.

THE SECTOGRAPH.

BY

LIEUT. T. J. TRESIDDER, R.E.

There is no doubt that irregular ground can only be properly represented in miniature by a model made to scale. A map, even when closely contoured, is not by itself a sufficiently finished representation of country for all purposes—it must be supplemented by sections, for which the contours furnish the data. But even if a model were as easy to make, and as portable when made, as a map, it could not take the place of the latter; because its irregular surface would be unsuitable for drawing upon.

Some means, then, of giving to a map the advantages of a model without its defects, appear to be wanted; and it is with the view of supplying this want that a scale has been designed—called the Sectograph—for use with contoured maps.

In order to gain conciseness without sacrificing clearness, the description of this scale is given in the form of answers to the three questions—

What is it for?
What is it?
How is it used?

What is it for?

1. If you have a contoured or numbered plan of any ground or work, and wish to make a section of it, it is to enable you to make that section with the least possible expenditure of time and labour.

2. If, under the same circumstances, you wish to solve certain problems regarding the plan, in the solution of which one or more sections would usually be necessary, it is to enable you to solve such problems without the trouble of drawing the sections.

What is it?

It is a rectangular piece of cardboard. Parallel to its longer edge, equidistant straight lines are ruled, the interval between them representing a certain number of feet on the scale of the plan. Call this set of lines *A*.

Perpendicular to these, another set of lines (not necessarily equidistant) is ruled. Call this set *B*.

For the sake of convenience, it is better to mark the lower long edge of the cardboard as an ordinary linear scale for the plan, and to prolong the divisions upwards to form the *B* set of lines. (This is done in the figure.)

The accompanying figure shows a sectograph lying on a contoured plan.

How is it Used?

1. Suppose you have a plan of ground contoured for every 25 ft., and that the distance between the lines of the *A* set in the sectograph corresponds to 25 ft. on the scale of the plan. It is required to make a section of this ground along a given line *XY*. (See figure.)

Place the lower edge of the sectograph along the given line, and mark on the sectograph with a pencil the elevation of each point where a contour cuts the given line.

Thus the elevation of the point "*a*" (see fig.) where the 400 contour cuts the given line, will be on the 400 line of the *A* set; and its position "*a*′" on that line will be determined by the lines of the *B* set on either side of it. Similarly, the elevations of *b*, *c*, *d*, *e*, *f*, and *g*, will be at *b*′, *c*′, *d*′, *e*′, *f*′, and *g*′ respectively. By joining on the sectograph the points thus determined, the required section is obtained.

In practice, a piece of tracing paper is laid on the sectograph, the points marked, and the section drawn on the former.

2. Suppose the plan and sectograph to be as in the first case. It is required to find whether a point "*a*" (400 ft.) on the plan, is in view of another point "*g*" (250 ft.) Place the lower edge of the sectograph so that it passes through both points, and adjust a "straight-edge" to pass through "*a*′" and "*g*′" (the elevations of "*a*" and "*g*" respectively). Then the "straight-edge" represents the elevation of the line of vision from "*a*" to "*g*."

Now, if the elevation (*b*′, *c*′, *d*′, *e*′, or *f*′) of any point (*b*, *c*, *d*, *e*, or *f*) is above the "straight-edge," the ground at that point obstructs the line of vision from "*a*" to "*g*," and these two points are not in view of each other. Otherwise they are.

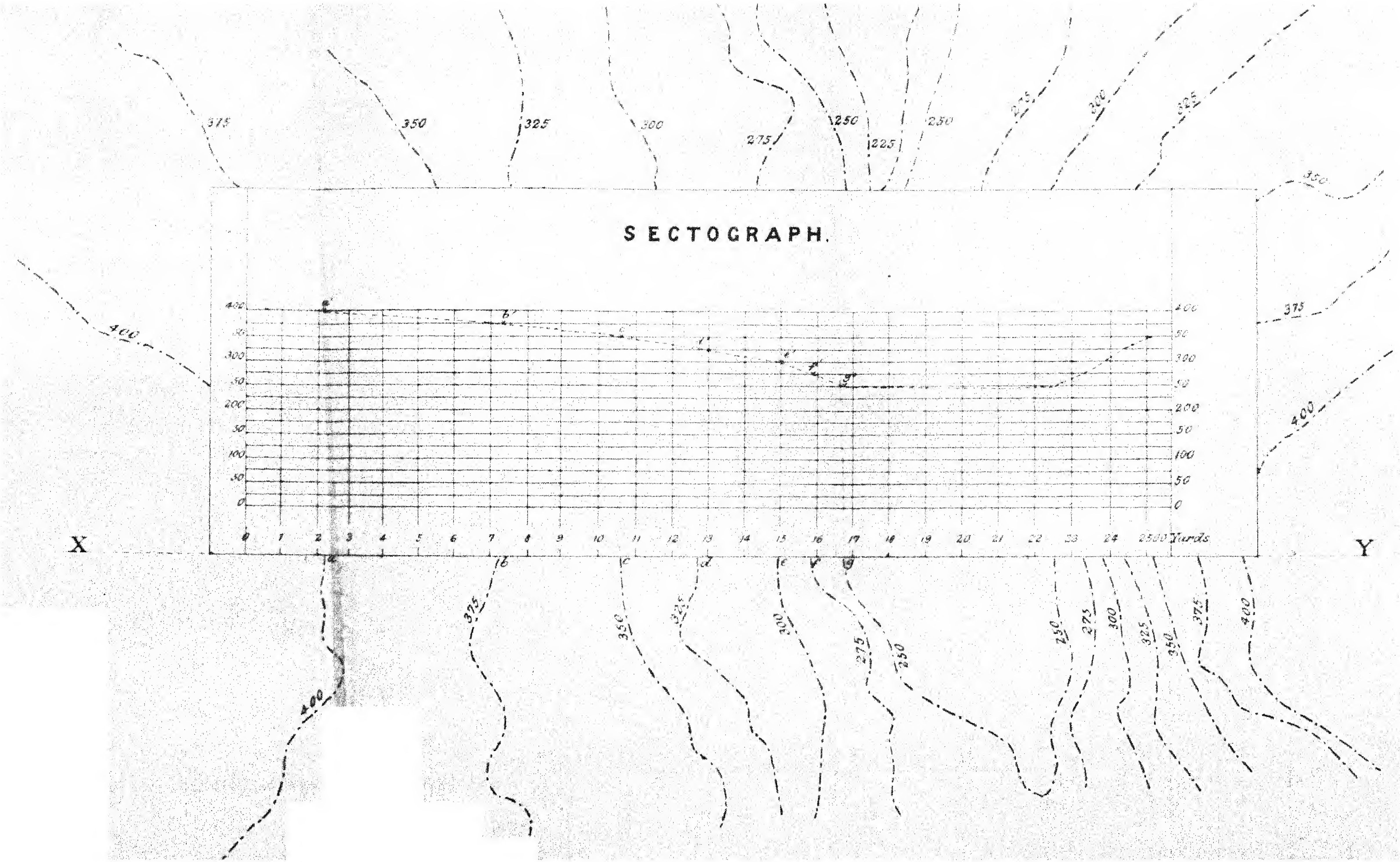
It is obvious that it is not necessary to mark any point on the sectograph itself; for in the first case the points are marked on the tracing paper, and in the second case they do not require to be marked at all.

The same sectograph will solve a problem of the second class on any map, no matter to what scale it is drawn.

This scale is extremely useful in determining "dead ground" in the adaptation of works to contoured sites, and for finding whether two hostile parties are in view of each other at Kriegs-spiel. An instrument on the same principle as the cardboard sectograph is now being constructed for use with the War Game, as it is feared that the laying down of a large piece of cardboard on the maps might interfere with the blocks representing the troops. It is intended to submit this instrument, when complete, for the approval of the Kriegs-spiel Committee.

WHITEHALL,

March 10, 1874.



SECTOGRAPH.
X
Y
Yards

A FLYING VISIT TO TURIN ARSENAL,

9TH NOVEMBER, 1873.

BY

LIEUT. H. GEARY, R.A.

HAVING occasion to pass through Turin in November last, I took advantage of the kindness of Captain Biancardi, of the Italian Artillery, and Director of Experiments, to visit the Arsenal under his guidance.

My stay in Turin being but of a few hours, the time available for inspection was proportionally brief; yet one could not fail in being astonished at the marvellous activity and progress displayed since a previous visit in 1868.

Although the British artillery authorities are doubtless well aware of the various improvements in *matériel* made in foreign arsenals, yet to the bulk of the officers of the regiment the archives of the department are practically inaccessible.

The following short notes, it is hoped, may consequently prove of some interest.

The heavy ordnance claimed the first and principal attention. Heavy ordnance.

The heavy guns in the Italian service are breech-loaders, on a system modified from that adopted by the French marine. The differences are only slight; the swinging breech and sliding breech-block remaining the same as in the French guns. They are all made of puddled steel, founded in France by "Petit-Gaudet," at "Rive de Gier," and at St. Etienne; but, for the future, steel manufactured from Elba ore, at Piombino in Tuscany, will be the sole material employed. A large coal field has recently been discovered in the vicinity of Piombino, and with it a prospect of great manufacturing activity. Breech-loaders. Piombino steel. Coal available on the spot.

It would be as well to give a few details of the principal gun yet manufactured.

Gun of 24 centimetres.

The piece of 24 centimetres calibre, though not the largest, is yet the gun which the Italians have produced in the greatest number. It may be considered the equivalent to our 9-in.

Dimensions.

Calibre	9·45 ins.
Weight	15 tons.
Projectile	330 lbs.
Length of bore	20 cals.
Charge	61·6 lbs.
Muzzle velocity	1413 f.s.
Number of grooves	24.

Contrast of length, compared with British guns.

At all events, inadequacy of length to consume the charge cannot be alleged with regard to the Italian gun. Would that the same could be urged in favour of its Woolwich rival.

Rifling uniform, and from R. to L.

The grooves are 24 in number, and the twist is from right to left, and uniform.

The grooves are ·8374 in. in width at the breech, narrowing up to ·6013 in. at the muzzle. This is obtained by making the driving edge uniform, whilst the other edge (the loading edge in M.L.O.) deviates from a parallel direction until the muzzle dimension is obtained.

Dimensions of the rifling.

The dimensions are :—

	in.
Width of groove at commencement of rifling	·8374
〃 muzzle	·6013
Width of land at commencement of rifling	·4090
〃 muzzle	·5280
Depth of groove	·0590

A considerable number of these guns have been made, and mounted on various works, and also form the armament of many vessels in the Italian navy. It is satisfactory to find that they have resisted "scoring," and similar injurious results of prolonged firing.

A gutta-percha impression of the breech-end of the bore, taken from a gun now in Turin Arsenal, showed perfect freedom from *all blemish*, save the expansion of the chamber the $\frac{1}{1000}$th of an inch, which is of no importance whatever.

The gun had fired the service projectile of 330 lbs., with charges of cubical powder (edge ·75 in.), no less than 538 rounds.

516 rounds	charge	57·2 lbs.
6 〃	〃	61·6 〃
16 〃	〃	66 〃

Test for breech action.

To test thoroughly the breech action, water and sand were thrown over the breech; yet nothing that was done prevented the efficient serving of the gun.

If it be deemed folly to adopt a breech-loading system, there at all events is a "*method in the madness*" of those who are so misguided.

Largest gun yet in the Italian service.

As before mentioned, there is a larger gun than that of 24 c. in the Italian service, which I was fortunate enough to see.

The length of bore is 20 calibres. Dimensions.

Calibre	12·608 ins.
Projectile	770 lbs.
Weight of gun	40 tons.
Charge	132 lbs. cubic powder.
Muzzle velocity	1382 f.s.

The gun has not yet been subjected to a trial similar to that described in the case of the 15-ton gun; but the quality of the metal is so exceedingly good, and the success of the Turin Gun Factory so uniform, that no sinister result is anticipated.

The gun will be subjected to searching proofs this spring at Santa Maurizio—the Shoeburyness of Italy. 40-ton gun tested at Santa Maurizio.

The shell employed with the larger ordnance merit attention, especially as ensuring stability and preventing windage. They are of cast-iron, with ogival head, and are provided with four or five rings of copper, running round the circumference of the shell. These copper belts are hammered by hand into undercut grooves cast in the body of the shell. Projectile for heavy ordnance. Four or five rings of copper.

The outer surfaces of these rings are cut into four grooves running round the shell, in order to allow, when fired, the surplus copper to be squeezed into them, and avoid "stripping."

Copper has been adopted instead of lead, in spite of its greater expense, consequent on the results of experiments made with projectiles fitted with copper rings and lead coats respectively. Why copper employed instead of lead.

The following table is compiled from an experiment at Santa Maurizio, with ten projectiles of each description, fired with equal charges, and from the same gun; range about 2000 yds. The result speaks for itself:— Experiment at Santa Maurizio.

		Lead.	Copper.
Mean deviation	Horizontal	·570	·184
	Vertical	·327	·248
"Accuracy" of fire deduced from Didion's formula		·39	1·90
Radius of circle containing half the total number of hits	Calculated	·78	·350
	Actual (*grafico*)	·77	·205

Captain Biancardi showed me a working model of a new muzzle-pivoting gun and carriage of his own invention, which by its simplicity and completeness bids fair to eclipse all its predecessors. The Italian Government have decided on giving it a trial with the new 40-ton gun; but until the experiment takes place, no detail is allowed to be given. Full details have, however, been promised, as soon as the trial is completed, which is expected to take place next month. New muzzle-pivoting system. To be kept secret till tried.

The working of the wrought-iron sliding carriage appeared very simple and satisfactory. It is fitted with a double hydraulic buffer, much simpler and lighter than the single one in use in the Wrought-iron sliding carriage. Double buffer.

British service. The piston rods are connected to a transom, which slides on rails inside the sides of the platform, and which can be connected at will with the carriage.

Action of buffer.

When the gun is "run up," the piston rods are home in the cylinders, which are fastened to the front of the platform. On firing, the transom (with the rods) slides up the sides of the platform, thus keeping the rods in their proper position, and preventing any jolting or unequal action. The weight of the gun and carriage is sufficient to "run the gun up" into the firing position without assistance, and the gradual return of the fluid through the piston-heads checks effectually the velocity attained. The platform has a slope of 8°.

The inspection of the method in use of ensuring the uniform burning of fuze composition, brought my visit to a close.

Method of ensuring uniform burning of fuze composition.

A definite quantity of composition is inserted in a leaden cylinder. This cylinder is extended by hydraulic pressure into a tube of considerable length. This is divided into a number of equal parts. One of these portions being placed in the head of a fuze in the form of a ring, is found to burn with extreme accuracy; being thoroughly protected from the increased pressure of the air, and the composition being uniformly distributed.

Time admitted of no further examination into many other objects of great interest to the artilleryman. Enough, however, was seen to persuade one that, young though Italy may be as a nation, the unrivalled genius of her people has left her little to learn in the artillery branch of military science.*

WOOLWICH,

November, 1873.

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* The bulk of the "plant" in use at the Turin arsenal is of native manufacture.

THE CONSTRAINED MOTION OF CONICAL WHEELS.

BY

LT.-COL. F. CLOSE, R.A.

PROFESSOR OF ARTILLERY, R.M. ACADEMY.

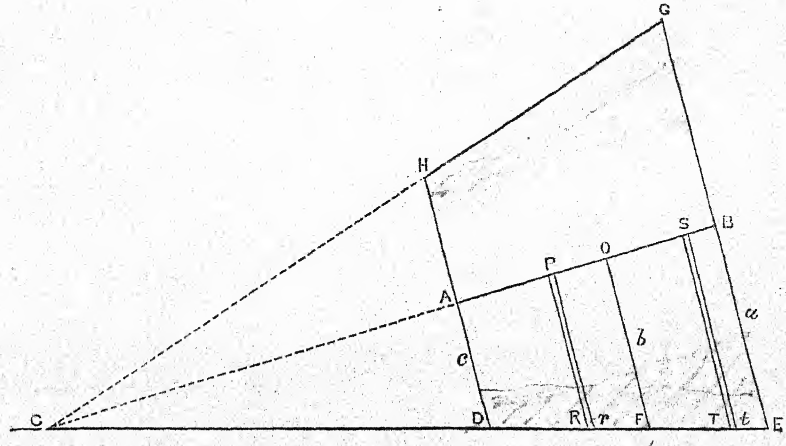
The particular form of wheel used throughout the British service has been chosen with the view of securing great strength and the best arrangement of its parts to withstand those more serious shocks to which it is especially exposed. The characteristics of this form are, considerable dish with little or no strut; this combination necessitating a corresponding inclination or "hollow" of the axletree-arm, and a tire, the exterior surface or periphery of which is conical.

The form thus adopted, while exhibiting great strength, is hampered with two disadvantages, each of which directly tends to increase the draught. These are—

(1) The "grind," or twist of the wheel.
(2) The side-rub.

Proceeding, then, to an investigation of the grind—which, so far as I am aware, has not been previously made—Fig. 1 represents an exaggerated

Fig. 1.



vertical section, *DEGH*, of any service wheel, *DE* being the part of the tire which is resting on the ground. The figure *DEGH* is, in fact, a principal section of the frustrum of a cone the apex of which is at *C*. *AB* represents the axis of the wheel.

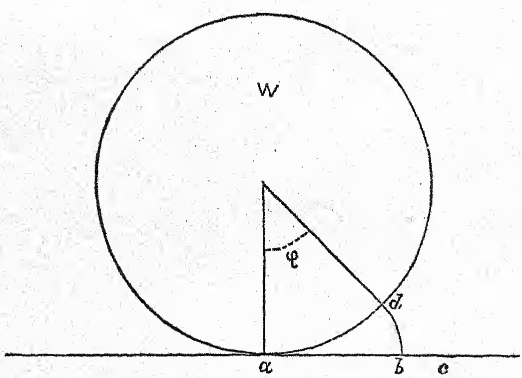
When the wheel is compelled to roll in a straight line on a rough plane, it is evident that there can only be one line in the surface of the tire which rolls truly. Let the point *F* represent the section of the rolling line.

The wheel may be considered to consist of an indefinitely great number of parallel laminal discs, perpendicular to the axis; and as all such discs pass over equal distances in equal intervals of time, it is evident that the discs between *E* and *F* revolve more rapidly than is necessary for them to cover, by rolling simply, that portion of the road covered by the rolling disc; and the discs between *D* and *F*, on the other hand, roll at a slower speed than is sufficient to cover by rolling the distance traversed by the rolling disc. Hence friction in opposite directions is set up on each side of the true rolling line, the tendency on one side being to increase, and on the other to retard the velocity of rotation; and the moments about the axis due to retardation must be equal to those due to acceleration.

In finding the position of the rolling line, *F*, on the surface, *DE*, of the tire, we may suppose the weight to be borne equally by every part of the touching surface along *DE*.

Fig. 2 represents any laminal disc (*W*) lying between *OF* and *AD*

Fig. 2.



(Fig. 1), the circumference of which is smaller than that of the rolling disc.

Let it be supposed that the rolling disc, in revolving through an angle ϕ, rolls a distance *ac* (Fig. 2). *W* must cover this distance; but it can only roll a distance *ab*, equal to that portion of its circumference which subtends ϕ. Therefore the distance *bc*, which is the difference between *ac* and *ab*, must rub the surface *ad* in passing it; and the frictional action generated in passing over *ac* could only be maintained in its full force for a distance *bc*. Hence, calling any distance *ac* equal to s, and *bc* equal to s_1,

$\frac{s_1}{s}$ = that co-efficient of the weight borne by any disc which at each instant is referable to friction.

Let $W =$ the whole pressure communicated by the wheel to the ground,
$\mu =$ co-efficient of friction between the surfaces of the tire and road,
$l =$ the length of the transverse section of the tire parallel to the axis,
$\Delta x =$ " " " any laminal disc.

Then,

$$W \cdot \frac{\Delta x}{l} = \text{weight borne by any laminal disc,}$$

$$W \cdot \frac{\Delta x}{l} \cdot \frac{s_1}{s} = \text{that fraction of the weight thus borne which at each instant is referable to friction,}$$

$$\therefore \mu W \cdot \frac{\Delta x}{l} \cdot \frac{s_1}{s} = \text{tangential friction exerted continuously upon the disc.} \qquad (1)$$

This applies equally to the discs on either side of the rolling line.

Let OS (Fig. 1) $= x$, $ST = y$, $AB = l$, $OB = n$, $FE = m$, and let $b =$ radius of the rolling disc. The cone, constrained to move in a straight line, is supposed to roll through an angle ϕ. Then the distance which has been travelled by the wheel is the distance which the rolling disc has rolled.

$$\therefore s = b\phi = \text{distance passed by every disc.}$$

And the disc at ST must have revolved a distance $ST \cdot \phi = y\phi$; therefore, being larger than the rolling disc, it must have *rubbed* a distance $\phi\,(y - b) = s_1$.

Therefore for each disc larger than the rolling disc,

$$\frac{s_1}{s} = \frac{y - b}{b};$$

and for each of those smaller than the rolling disc, by similar reasoning,

$$\frac{s_1}{s} = \frac{b - y}{b}.$$

Substituting for $\frac{s_1}{s}$ its values in equation (1),

$$\text{Tangential friction} = \frac{\mu W}{l} \cdot \frac{y - b}{b} \cdot \Delta x, \text{ on the one side,}$$

$$\text{and} \quad " \quad " \quad = \frac{\mu W}{l} \cdot \frac{b - y}{b} \cdot \Delta x, \text{ on the other side.}$$

Taking first a disc Tt on the larger side, the moment of its friction about the axis at S is the tangential friction multiplied by y

$$= \frac{\mu W}{bl} \cdot (y - b)\, y \Delta x.$$

Now,

$$\frac{\Delta y}{\Delta x} = \frac{y}{x} = \frac{a - b}{n},$$

$$\therefore \Delta x = \frac{n}{a - b} \cdot \Delta y.$$

Consequently, the elementary moment

$$= \frac{\mu W n}{bl\,(a-b)}\,(y^2 - by)\,\Delta y\,;$$

and in the limit,

$$= \frac{\mu W n}{bl\,(a-b)}\,(y^2 - by)\,dy.$$

Therefore the whole moment from b to a

$$= \frac{\mu W n}{bl\,(a-b)} \int_y (y^2 - by) \left\{ \begin{array}{l} \text{from } y = a \\ \text{to } \ y = b \end{array} \right.$$

$$= \frac{\mu W n}{6lb}\,\{2a^2 - ab - b^2\}.$$

Similarly, the whole moment from A to O

$$= \frac{\mu W\,(l-n)}{bl\,(b-c)} \int_y (by - y^2) \left\{ \begin{array}{l} \text{from } y = b \\ \text{to } \ y = c \end{array} \right.$$

$$= \frac{\mu W\,(l-n)}{6lb}\,\{b^2 + bc - 2c^2\},$$

and by the conditions these moments are equal; therefore

$$n\,\{2a^2 - ab - b^2\} = (l-n)\,\{b^2 + bc - 2c^2\}.$$

If for b, its value, $a - \dfrac{n\,(a-c)}{l}$, be put in this equation, and it be as far as possible simplified, we get

$$n = \frac{l}{3} \cdot \frac{(a^2 + ac - 2c^2)}{a^2 - c^2};$$

$$\therefore\ n = \frac{l}{3} \cdot \frac{a + 2c}{a + c},$$

$$\text{and } l - n = \frac{l}{3} \cdot \frac{2a + c}{a + c}.$$

Thus the position of the true rolling line is defined in terms of the breadth of the tire (l), and the large and small radii of the wheel, viz. a and c.

To ascertain now the pressure exerted upon the pipe-box by the grind of the wheel.

We have already found the tangential friction upon any elementary disc ST (larger than the rolling disc) to be equal to

$$\frac{\mu W}{lb}\,(y - b)\,\Delta x.$$

The moment of this friction about an axis OF in the plane of the rolling disc is the product of the force of friction and the perpendicular upon its direction from the axis. This latter equals $OS = x$.

The moment, therefore, about OF due to the friction at T

$$= \frac{\mu W}{lb} (y - b)\, x \Delta x.$$

But

$$b + x \,.\, \frac{a - b}{n} = y,$$

$$\therefore\ y - b = x \,.\, \frac{a - b}{n}.$$

Therefore the moment of T about OF

$$= \frac{\mu W}{lb} \frac{(a - b)}{n} x^2 \Delta x;$$

and in the limit,

$$= \frac{\mu W\,(a - b)}{bln} x^2 dx.$$

Therefore the whole moment due to FE

$$= \frac{\mu W\,(a - b)}{bln} \int_x x^2 \,.\, \left\{ \begin{array}{l} \text{from } x = o \\ \text{ to } \ x = n \end{array} \right.$$

$$= \frac{\mu W\,(a - b)}{3bl} \,.\, n^2.$$

Similarly, the whole moment due to FD

$$= \frac{\mu W\,(b - c)}{3bl} (l - n)^2,$$

and the whole moment about an axis intersecting, and at right angles to, the axis of the axletree-arm, is equal to the sum of these moments. Calling the whole moment "Σ," we have

$$\Sigma = \frac{\mu W}{3bl} \{ (a - b)\, n^2 + (b - c)\, (l - n)^2 \}.$$

Remembering that $b = a - \dfrac{n\,(a - c)}{l}$, we eliminate b in this equation; and then substituting for n and $(l - n)$ their respective values already found,

$$\Sigma = \frac{\mu W l}{6} \left(\frac{a - c}{a + c} \right).$$

But if the angle of the hollow of the arm—its inclination to the horizontal plane—be called "α," then $(a - c) = l \tan \alpha$; also, calling "h" the mean height of the wheel, $(a + c) = h$.

The whole moment, therefore, about an axis intersecting, and at right angles to, the axis of the axletree-arm, is equal to

$$\frac{\mu W}{6} \,.\, \frac{l^2 \tan \alpha}{h};$$

l being the breadth of the tire.

Hence this moment varies directly as the square of the breadth of the tire, directly as the tangent of the hollow of the arm, and inversely as the height of the wheel.

It produces a continuous pressure on the back of the axletree-arm at the shoulder, and on its front near the point; these pressures being applied at the ends of the pipe-box. They vary directly as the moment, and their effect is to retard the movement of the carriage and to wear down the pipe-box or axletree-arm. Their amounts in each particular case can be readily found from the values of Σ and n, already given, provided μ be first ascertained. This can be done by trial, if not already known.

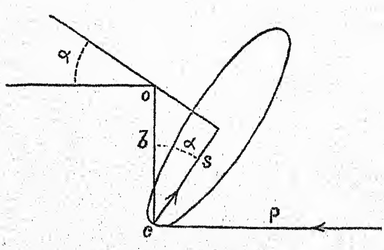
If, then, on grounds of strength, a certain hollowing of the axletree-arm be unavoidable, we see at a glance, from the terms in which the value of the moment is expressed, how essential it is to confine the width of the tire within the lowest allowable limits; also that, besides the ordinary conditions of traction, showing clearly, as they do, the advantages conferred by high wheels as compared with low, an additional reason for their use is found when the axletree-arm is hollowed. With field artillery carriages, fortunately, great height of wheel is admissible. Not so, however, by any means generally among the transport carriages of the service. And here, accordingly, it becomes an object of importance to reduce the breadth of the tire as far as other considerations will permit, in order to neutralise the excessive action of the grind.

When, however, small wheels are connected with the fore-carriages of wagons having hind wheels of large diameter, other important considerations —such as the expediency of securing a uniform width of tire to make the track, and to simplify, as far as may be, the dimensions of material required for repairs—render it obligatory to make the width of the tire of the front, equal to that of the hind wheel.

Now, it is clearly unnecessary to construct the front wheel of such a form as to withstand *greater* strains than those which the hind wheel is computed to bear effectively; because the chief portion of the load is always borne by the hind wheels in properly designed wagons of the type referred to here, and all the strains on the wheels are proportional to the weights they sustain.

If, then, the front wheels are designed to bear equal strains with the hind wheels, they will be well within the limits of safety.

Fig. 3.



A brief inspection of Fig. 3 will show that the strength—*i.e.*, the capability of resisting lateral thrusts—possessed by a dished wheel shod with

a ring tire, and having its lower spoke vertical, is proportional to the sine of the angle of hollow, the strength of such wheel being dependent on the amount of resistance to extension exerted by the tire.

Thus, if P represent the pressure or blow applied at c, and tending to bend or break the spoke b at the point o, and S be the normal resultant of the resistance to extension opposed at c by the tire, then

$$P = S \sin \alpha;$$

α being the angle of hollow.

Further, we must bear in mind that the forces giving rise to this normal resistance in the tire actually produce a longitudinal extension of it proportional to its length, which, again, is proportional to the diameter of the wheel. Accordingly, the effective resistance of the tire, and therefore the strength of the wheel, is also inversely proportional to its height.

If, then, S_1 and S represent the strength of two wheels of different diameters—for instance, the front and hind wheels of a wagon—having the same sectional dimensions of tire, the hollows of their arms and diameters being respectively α_1 and α, and h_1 and h, we have

$$S_1 : S :: \frac{\sin \alpha_1}{h_1} : \frac{\sin \alpha}{h};$$

and therefore if two such wheels are to possess the same strength,

$$\frac{\sin \alpha_1}{h_1} = \frac{\sin \alpha}{h},$$

$$\text{or} \quad \frac{\sin \alpha_1}{\sin \alpha} = \frac{h_1}{h};$$

$$\therefore \sin \alpha_1 = \frac{h_1}{h} \sin \alpha.$$

This value of α_1 shows the amount of hollow which should be given to the axletree-arms of the fore-carriage in order that its wheels should be equally strong with the wheels running behind them.

We have already ascertained that the grind-pressure on the axletree-arms is proportional to the tangent of their hollow. Hence, when the tire of the front wheel must needs be kept as broad as that of the hind wheel, every constructive principle demands that the hollow of the arm should not exceed the amount imposed by the conditions of strength. These conditions we now see are satisfied if the sines of the hollows are proportional to the heights of their respective wheels.

Thus in the 3 ft. 4 in. and 4 ft. 8 in. wheels of the service, the hollows of the arms should be as five to seven, at the outside; and, indeed, the proportion might be still further reduced with perfect safety and much benefit to the draught.

With regard to the advantages derived from the hollow and strut—which, strange to say, are disputed in some quarters—an experience of several years in carriage manufacture and in the conduct of various prolonged and

carefully observed experiments with wheels, has led me to the following conclusions:—

1. In the case of carriages loaded heavily and drawn over irregular and broken ground, a dish is of the utmost value to strengthen the wheel, *whether the carriage be on springs or not.*

2. In carriages not supplied with springs, but liable to carry dead loads over all sorts of country, the lower spoke should be almost, but not quite, vertical. Consequently, with the requisite dish, the amount of hollow to be given to the axletree-arm will be measured by the difference between the "dish" and the "strut."

3. If the carriage be on easy springs, considerable dish of the wheels is admissible without hollowing the arm. The wheels would then be cylindrical, and would roll truly. In this case, the strut of the lower spoke is equal to the dish of the wheel.

WOOLWICH,

February 3, 1874.

110. Note on the new Method of Controlling the Recoil of Heavy Guns at Proof, by Major E. Maitland, R.A.

Up to the present time, heavy guns have been carried down by rail from the Gun Factories on trucks to the butt, and have then been mounted for proof by means of a crane (constructed to lift 30 tons), on a strong iron carriage, fitted with expanding sides, to take guns of weights varying from 12 to 38 tons.

It is now proposed to extend the rails opposite the firing bays, so that a heavy gun may be fired from a specially constructed travelling truck; thus dispensing with the expanding carriage and crane altogether. The axis of the gun on the truck will be parallel to the rails, and the truck and gun will recoil along the line. There are three adjacent bays formed to receive the proof projectiles of heavy guns. In order to utilize them all, it is only necessary to curve the line of rail sufficiently to permit lines drawn from the bays to form tangents to the curve; the distance of the firing points from the butt being enough to render the angle of incidence unimportant.

By carrying back the rail in a curve of contrary flexure, a second series of firing points is obtained, at an increased distance from the bays. The railway is then carried back in a straight line, so that from the most distant firing point the recoil may be direct. On account of the nature of the ground, it is found expedient to bring the gun to a standstill within a distance of 120 ft. from the rearmost firing position. Assuming the weight of the heaviest gun likely to be used at 80 tons, and the weight of the truck at 5 tons, we have $W = 85$. Supposing this gun to throw a shot of 1600 lbs., with a muzzle velocity of 1400 ft., we have

$$\text{initial velocity of recoil} = V = \frac{vw}{W} = 11{\cdot}76 \text{ f.s.}$$

Hence the work contained in the gun and truck at starting will be

$$\frac{WV^2}{2g} = 182{\cdot}6 \text{ foot tons.}$$

Allowing a margin for exceptional cases, we will put this energy at 250 foot tons.

The work done in stopping the recoil is given by the formula

$$W(\sin\alpha + \mu\cos\alpha)\,S,$$

which may be put

$$W(y + \mu x);$$

μ being the co-efficient of friction, which, with strong rough rails and truck wheels, will not be less than $\frac{15}{2240}$, or $\cdot 0067$. Hence

$$\frac{WV^2}{2g} = W(y + \mu x).$$

and this will give the height of the slope (or y) at any given distance x, whether the railway be horizontal, or carried up an inclined plane, or so constructed that the incline be an upward curve.

In the present case, since $x = 120$ ft.,

$$y = \frac{250}{85} - \cdot 0067 \times 120 = 2{\cdot}14 \text{ ft.};$$

$$\therefore \tan\alpha = \frac{2{\cdot}14}{120}, \text{ and } \alpha = 1^\circ\ 1'{\cdot}5.$$

Suppose, now, that it were necessary to bring the gun up at 15 ft., we should have

$$y = \frac{250}{85} - \cdot0067 \times 15 = 2\cdot84\,;$$

and α would be 10° 43′.

In this case it would probably be found expedient to construct the railway so that it should curve upwards, and the semicubical parabola would be found to be a highly suitable curve for the purpose. Its equation is

$$y^2 = a^2 x^3\,;$$

$$\therefore\ a^2 = \frac{y^2}{x^3} = \cdot00239,$$

$$\frac{dy}{dx} = \frac{3a \times \frac{1}{2}}{2} = \tan\theta.$$

Hence the angle of ascent would increase from 0 to 15° 31′.

Returning to our heaviest gun, and assuming that, contrary to expectation, the recoil has carried it to the summit of the slope, we have next to calculate, on its running down again, what velocity it will acquire by the time it reaches the bottom. It is evident that gravity will bring it down, and friction will retard it. Hence we have

$$\text{acceleration} = g\,(\sin\alpha - \mu\cos\alpha) = v\,\frac{dv}{ds}.$$

Integrating,

$$S = \frac{v^2}{2g\,(\sin\alpha - \mu\cos\alpha)} + C.$$

$$\text{When } S = o \quad v = o, \ \therefore\ C = o\,;$$

$$\therefore\ v = \sqrt{2gs\,(\sin\alpha - \mu\cos\alpha)}\,;$$

and putting $S = 120$ (strictly 120 sec 1° 1′·5), $v = 9\cdot26$ at the bottom of the slope.

The gun will then travel over about 100 ft. on the level, and will then rise up another inclined plane made to consume the remaining energy; after which, it will run down again, and come to rest not far from its first position when fired.

In the foregoing calculation the resistance of the air is neglected, being small and on the right side.

111. New Iron Siege Carriages. By Captain W. Kemmis, R.A.

The following iron carriages are proposed for the siege train, and of them the first named has recently been approved, namely :—

Nature.	Weight, empty.		
	cwt.	qrs.	lbs.
40-pr. M.L.R. of 34 cwt., gun-carriage	24	2	0
64-pr. M.L.R. of 64 cwt. (II. & III.), gun-carriage...	30	2	0
8-in. M.L.R. of 46 cwt., howitzer-carriage..............	40	1	14
Siege limber	11	0	14

40-pr. M.L.R. Gun-Carriage.

This carriage is constructed in the same manner as the 9-pr. M.L.R. carriage Mark II. (described in a previous "Short Note;") that is to say, the brackets have the plate—which is lightened out—on the inner side of the angle-iron frame, the axletree-bed is of wrought-iron, and the trail-piece fits between the points of the brackets instead of lapping over them.

The transoms—of which there are two—are each formed of plate, riveted to a three-sided frame of angle-iron. They are riveted to the brackets, the connection of the second transom to the latter being strengthened by small bracket stays, while the front transom is riveted to the bed. A bracket stay is also riveted to the front, and another to the rear, of the axletree-bed, and to each bracket, in order to unite the bed more firmly to the brackets.

The wheels are the Madras pattern, 1st class, 5 ft. high, shod with ring tires 6 ins. wide; the flanges of the nave do not project beyond the pipe-box; their track is 5 ft. 2 ins.

The trunnion-holes—as in the wooden siege gun-carriages—are "firing" and "travelling," the height from the ground to their axis being 4 ft. 5 ins.

The gun is elevated or depressed by means of an elevating arc attached to it, which passes between a pinion and a friction wheel upon the inside of the right bracket. The pinion is turned as required by means of a worm-wheel and worm-shaft with hand-wheel.

The carriage is fitted with two trail handles, an iron box for a spanner, and rests in which to carry the elevating arc when the gun is in the travelling trunnion-holes. The fittings for the drag-shoe and chain are upon the left of the carriage.

64-pr. M.L.R. Gun-Carriage.

This carriage is similar to that for the 40-pr., and has the same height of axis of the trunnion-holes.

8-in. M.L.R. Howitzer-Carriage.

The carriage proposed for the 8-in. howitzer differs from the two preceding in having brackets of double-plate construction with wrought-iron frames, and in the axletree and its bed, which is formed merely by a piece of angle-iron riveted along each side of the axletree, passing through instead of lying beneath the brackets, while a bottom plate is added, extending from the rear transom to the breast of the brackets. This construction is rendered necessary, as it is intended that the howitzer should be fired from the carriage with the wheels off as well as on.

The lower parts of the brackets are extended to the front, to prevent the carriage tipping when the howitzer is fired, the wheels not being on; and the bottom plate is rounded in rear, to prevent it injuring the ground platform.

The rear transom has angle-iron riveted across the top in rear, which is also riveted to the brackets, and both transoms are secured by double angle-iron.

The elevating gear is similar to that for the 40-pr. and 64-pr.; but, while attached to the right side, it is worked at the left.

Siege Limber.

The siege limber is constructed in the same manner as the field limber Mark II. (described in a previous "Short Note.") In addition to being riveted into the bed, the axletree is further secured by a clip near each shoulder.

The wheels are the heavy field wheels, Madras pattern (*i.e.*, the same as for 16-pr. M.L.R. limber).

The splinter-bar is fitted for four-horse draught, in the same manner as the wooden siege limber.

112. Formulæ for Computing the Number of Barrels piled in Magazines, by Captain S. E. Pemberton, R.A.

Case 1.—Pyramid pile.

$$S = 1 + 2 + 3 \,\ldots\ldots\ldots + n;$$

where S = number of barrels,

n = number in bottom row.

$$\therefore\ S = \frac{n(n+1)}{2}. \quad \ldots\ldots\ldots\ldots\ldots(1)$$

In an incomplete pyramid pile,

$$S = \frac{n(n+1)}{2} - \frac{(m-1)m}{2} = \frac{n^2 - m^2 + n + m}{2}$$

$$= \frac{(n+m)(n-m+1)}{2}; \quad \ldots\ldots\ldots\ldots\ldots(2)$$

where m = number in top row.

Case 2.—Where *one* end of the pile rests against an upright, and *the top row does not touch* the upright.

$$S = n^2 - m^2;$$

where n = number in bottom row, and m number in top row.

Suppose the pile continued till $m = 1$. Then,

$$S = 2(1 + 2 + 3 \,\ldots\ldots\ldots + n) - n - 1$$

$$= n(n+1) - (n+1) = (n+1)(n-1) = n^2 - 1; \quad \ldots\ldots\ldots(3)$$

and in an incomplete pile,

$$S = (n^2 - 1) - (m^2 - 1) = n^2 - m^2. \quad \ldots\ldots\ldots\ldots(4)$$

Case 3.—If the top row touch the upright.

$$S = n^2 - m^2 + m. \quad \ldots\ldots\ldots\ldots\ldots(5)$$

Case 4.—Where the barrels are piled *between two uprights* so that if bottom row $= n$, second $= n - 1$, third $= n$, and so on.

If top row $= n - 1$—*i.e.*, if top row do not touch the uprights,

$$S = mn - \frac{m}{2} = \frac{m}{2}(2n - 1); \quad \ldots\ldots\ldots\ldots\ldots(6)$$

where m = number of courses.

When top row $= n$—*i.e.*, when top row touches uprights,

$$S = mn - \tfrac{1}{2}(m - 1) = \frac{m(2n-1)+1}{2} \,. \ldots\ldots\ldots\ldots(7)$$

These results, being only calculated for piles of one barrel in depth, must of course be multiplied by the number of barrels in the *depth* of the piles.

NOTES ON THE APPLICATION OF INDIRECT FIRE,

BY

LIEUT.-GENERAL V. DECKER.

TRANSLATED BY

LIEUT. H. TORKINGTON, R.A.*

For many years past, curved fire has been the subject of the most searching experiments by the Prussian artillery; but its first practical application was in the war with France, 1870, at the siege of Strasbourg.

Though the results obtained at the experiments on the practice ground were favourable, yet there were not wanting many shrewd men who doubted the possibility of a successful application of this method of fire in actual warfare. However, the results obtained before Strasbourg bore out the views of the most sanguine, and proved the great advantages that may be obtained from the adoption of indirect fire as there employed.

As far back as the year 1864 it had been foreseen that, in future, indirect fire must necessarily be frequently employed, and at the same time the question was raised as to whether it might not be desirable to introduce a rifled gun, shortened so as to be used with considerably lower charges; and to test the working of this theory, experiments were carried on until the end of 1869, which resulted in the shortened 15 c.m. gun being considered as the best for the purpose, and it was introduced into the service in February 1870. This is not the place to enter into details of the construction of this piece (which may be found described in the "Historical Sketches on the Development of the short 15 c.m. gun;")† but a few remarks may be made on its projectile and carriage.

It fires a long shell specially constructed for it by Captain Müller, which, though only a trifle heavier than the ordinary shell (62·5 lbs.),

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* All weights and measures are converted into English equivalents.

† "Historische Skizze uber die Entwickelung der kursen 15 c.m. Kanone."—Berlin, Mitter und Sohn.

yet contains more than double the charge, averaging 4·4 lbs. It must be also taken for granted that the construction of the trail is known; but the patterns used before Strasbourg had been further provided with an arrangement the scales of which allowed a line of fire once found correct to be retained accurately.*

At the outbreak of the war there were none of these shortened 15 c.m. guns ready, but a small number were in course of construction, intended to replace the heavy howitzers and mortars then in use; and the completion of these was so hastened that the first twelve pieces with their equipment were sent from Spandau to the siege train before Strasbourg on August 31st, 1870. They fell in with the siege train at Vendesheim on the 3rd September, and by the 9th some of them were already in use against the fortress. Being intended only for indirect fire, the amount of ammunition issued to them was limited; it was therefore out of the question to employ them for the ordinary purposes of the siege, and it was only in particular cases that they were brought in opposition to the enemy's guns. The execution of such duties as could only be accomplished by indirect fire fell specially to them. The most important of these were—1st, the destruction of the redoubt in Lunette No. 44 (the Railroad Lunette); 2nd, indirect breaching at long ranges.

It must be mentioned that Captain Müller was appointed to command these twelve 15 c.m. guns in addition to the siege train at Strasbourg. This officer had drawn up the report on the experiments made with these guns by the experimental Committee, and had also superintended their construction; he was therefore well acquainted with their capabilities and special uses, and in his capacity of commanding officer had every opportunity of disposing of these guns to the greatest advantage in the different attacking batteries. The favourable results obtained were entirely due to the great experience he had gained when serving on the experimental Committee, combined with the scientific and efficient manner in which he directed the employment of these guns, and explained the method of utilising their fire most advantageously to the other officers.

He was one of the first officers decorated with the iron cross for his services before Strasbourg, and most of the following details are borrowed from his special report.

The Destruction of the Redoubt in Lunette No. 44.

Lunette No. 44, together with its redoubt, were very harassing to the attack in the advance from the first parallel. Many sorties were

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* This apparatus consists of a trapezoidal iron frame hanging from the axletree, on the lower side of which is a graduated scale; a similar scale being fixed parallel to it on the rear extremity of the trail. It is used as follows:—A line is traced on the platform, and as soon as the aim, &c., is found to be correct by ordinary observation, the points where the scales cut the above line are noted; and in succeeding rounds it is only necessary to trail right or left, and bring the scale on the trail to a position such that it makes with the axletree scale a corresponding difference to the one already noted.—*Note by Translator*.

made under its protection, and indeed the most distant parts of the attack were enfiladed by it. To take it by storm appeared impracticable, from its construction (a revetted scarp, and loopholed counterscarp); but it was not desirable to extend the plan of attack so as to include it, as this would have absorbed an undue proportion of men and *matériel*, and delayed the advance of the main attack considerably. Therefore the artillery was entrusted with the task of rendering the work in question harmless and untenable. A brisk fire from several batteries of the first parallel had been directed against it from the first, but no noticeable result was obtained; for although the fire from the fort at times appeared to be silenced, it invariably reopened with renewed vigour. Indeed, it was frequently asserted that the lunette was forsaken by the enemy, and might be taken possession of without more ado; but reconnaissances proved the contrary. The arrival of the short 15 c.m. guns, which was immediately followed by that of the rifled 21 c.m. mortars, provided the means for more energetic and successful attempts against the work.

For this purpose the mortar battery No. 5 was, during the night of September 6–7, converted into a gun battery, armed with four 15 c.m. guns; its main object being the reduction of No. 44 Lunette, and destruction of its redoubt. The command of this battery, which opened fire on the morning of the 7th September, was given to Captain Müller, already mentioned.

The two 21 c.m. mortars were placed in Battery No. 35, constructed purposely for them on the night of September 7–8, and opened fire on Lunette No. 44 on the following morning at 9 o'clock. This fire was kept up till the 9th September, and was then directed against Bastions Nos. 11 and 12. Thus any assistance received from these mortars in this short time could only have been very slight, and may be disregarded by us—more especially as the present essay treats only of 15 c.m. guns.

From plans and information at hand it was known that Lunette 44 lay between the two hornworks on the north-east front of Strasbourg, and about 300 yds. in advance of them. It consisted of two faces and two short flanks, in front of which was a dry ditch 15 paces wide, with a revetted scarp 20 ft. and counterscarp 16 ft. high. Its gorge was closed by a loopholed wall 12 ft. high, and a casemated redoubt. It was supposed that there existed hollow traverses on each face of the rampart, and that the terreplein of the work was free and open. All these conjectures proved, on the capture of the place, to be tolerably correct; but it was found that the two faces met at a much more acute angle than that given in the plan, and on the terreplein was discovered a sort of traverse on the line of the capital (*kapital traverse*), which had in all probability been roughly constructed during the siege for the better protection of the work.

The existence of this protecting traverse had, however, already been suspected by the battery; because when some portions of the parapet of the lunette had been carried away by the fire previously opened on it from the battery behind the first parallel, it was observed that there was a heap of earth beyond, and a closer reconnaissance of the lunette,

which became practicable later on, from the top of a railway shed, proved the fact. As to the redoubt, it was only known that it lay lengthwise in the gorge of the lunette. Of its proportions in profile nothing was known; so that there was very little previous knowledge to guide the indirect firing on the redoubt. From what had been ascertained before, and from the reconnaissance from the top of the railway shed, it was concluded that the distance of the redoubt from the traverse on the terreplein amounted to about 25 paces; and in order to strike the masonry work half-way up, an angle of incidence of from 11° to $11\frac{1}{2}^\circ$ would be necessary to the trajectory of the shot. The proportionate charge for the distance between the battery and the crest of the lunette (960 yds.) was reckoned at 1·543 lbs. This gave an angle of incidence of $11\frac{3}{16}^\circ$, with a terminal velocity of 475 ft. per second.

In the first place, in order to get the exact range, some shots with the maximum charge of 3·3 lbs. were fired against the embrasures of the lunette, followed by a few with a charge of 1·543 lbs. To observe and correct these shots was at first very difficult; because it could not be exactly distinguished whether shots whose explosions were partly visible, throwing up a quantity of earth, had hit the earthwork of the redoubt or the sheltering traverse, and no certainty on this point could be gained till later observations were made from some trenches outflanking the lunette. It was also difficult to determine the elevation to use against the redoubt; partly on account of the acute angle formed by the two faces, and partly from the position of the battery, in the prolongation of the capital of the lunette.

However, in spite of all difficulties, soon after the arrival of the 15 c.m. guns the lunette remained almost silent; therefore, on the 12th September, two guns of No. 5 Battery were sent back to the park, the other two remaining to assist in suppressing the fire of some guns which had appeared on the cavaliers in Nos. 8 and 9 Bastions, and some mortars which had been placed in position on the curtain between these two bastions. They were also, from time to time, required to resume their fire against the lunette, whenever the enemy attempted to open fire from it; but such attempts were very feeble, and generally very soon silenced again.

The number of rounds fired by the 15 c.m. guns against the lunette, and its redoubt in particular, cannot be exactly estimated, because, as above mentioned, these guns were at times used for other purposes; but whatever their number, their effect was very evident. The traverse and right half of the work were most seriously injured; great gaps had been made in the loopholed wall across the gorge, which the French had endeavoured to fill up at a great expense of sand-bags; and finally, the right flank of the redoubt had been completely destroyed. Whether the capitulation of the redoubt was caused by the short 15 c.m. guns or by the two 21 c.m. mortars it is impossible to say, as they were employed against it at the same time; but the former had certainly by far the greatest share in injuring the interior of the lunette, and the destruction of the gorge wall was entirely due to them.

Breaching by Indirect Fire at Long Ranges.

Indirect firing was employed to breach—

1. The right face of Lunette No. 53,
2. " " " Bastion " 11,
3. " left " " " 12;

and in all three cases the same plan of working the guns was adopted —viz., that employed in the experiments at Silberberg, November 1869, and afterwards laid down for general use. The worth of these experiments was immediately and extensively tested at the breaching of Strasbourg, and it can be justly asserted that to their accuracy the favourable results obtained are in great measure to be attributed. To form a breach, the old approved principle was adhered to, of first cutting a horizontal and then two vertical cannelures in the scarp; the horizontal one one-third of the height from the foot of the wall, and the others upwards from its extremities. The most difficult part of the work was the impossibility of seeing the part of the scarp in which the horizontal cannelure had to be cut.

On account of the natural divergence of the shot, this could not be done, as in direct breaching, by a single series of contiguous shot-holes; but by discharging several shots with unaltered aim, a series of groups of holes was formed, by means of which the cutting was made.

Before commencing this, the range of the visible parts of the wall was obtained; the necessary alterations of elevation to hit the scarp at the height proposed for the horizontal cutting was then ascertained, and several rounds fired with the elevation thus found formed a group of hits, from which the cutting was extended on both sides horizontally to the proposed breadth of the breach.

If it was ascertained by actual observation that the position of these groups was correct, the elevating screw was clamped, and the slightly higher elevation necessary for the increase of range, as the shots became further removed from the perpendicular, was regulated by the quadrant, whilst the direction was obtained by the scales of the new pointing apparatus described above, which allowed of its being kept very regularly and uniformly, thus ensuring the contiguity of the groups of shot; and, as a further precaution, a table was formed, immediately after the trial shots, showing the necessary alteration of elevation for each round, copies of which were given to captains of batteries, who regulated their firing accordingly, and at the same time made any alterations which actual observation showed to be necessary. From the above it will be seen that in future it was only necessary to examine the tables in each battery a few times daily to ascertain how many times the length of the cutting had been fired through.

It was judged whether the horizontal cannelure was sufficiently cut to allow of the commencement of the verticals—firstly, by the experience obtained in peace time of the effect of fire on masonry; secondly, by the knowledge of the velocity of the shot, the strength of the particular wall, &c., &c.; and thirdly, from any possible observations of the effect

produced. A few extra rounds were then fired, to ensure the completion of the cutting and to guard against any chance of failure.

The particular signs which proved that a breach had been effected in a wall, had been noted during the experiments at Silberberg; and when the appearance of these signs, added to the consideration of the number of rounds fired, and other circumstances, justified the supposition that the breach had been effected, then once again a series of shots was systematically fired from one end of the horizontal line to the other; and during this the most careful observations were made of the striking and exploding of the projectiles, the appearance of the masonry displaced, and the colour, &c., of the smoke rising from the ditch. The variations of these signs, though only very slight, are as follows:—

(*a*) The concussion and report of the exploding shell is sharp when striking firm masonry, but dull and faint when the wall is partially damaged or quite cut away (in which latter case the explosion of course takes place in the earth at the back of the wall).

(*b*) If the masonry is not quite penetrated, stones and splinters are thrown up high out of the ditch.

(*c*) The smoke of the explosion appears above the wall more or less quickly, according as the latter is more or less deeply cut. In the case of an unbroken wall, the colour of the smoke is a bluish white—as gunpowder smoke usually is—and rises in a thick mass; whereas, as soon as the wall is penetrated, the smoke appears less quickly, it is dark grey in colour, and rises slowly out of the ditch, as out of a chimney.

When it was quite clear that the horizontal cutting was completed, the verticals were commenced, and usually very quickly formed.

Breaching the Right Face of Lunette No. 53.

The engineer work was so far advanced that on the night of September 11–12 the third parallel, 725 paces long, was opened before the Lunettes Nos. 52 and 53. This was therefore the moment for the artillery to undertake the breaching of Lunette No. 53, which it was very necessary to take first of all. For this purpose the Mortar Battery No. 8 was converted into a gun battery, armed with four short 15 c.m. guns, and manned by the 9th Company of Garrison Artillery of the Guard (First.-Lieut. von Ihlenfeld). From plans and reconnaissances, the following dimensions of the profile of No. 53 Lunette were arrived at:—Taking the cordon of the escarp at $\pm$ 0 ft., the crest of the parapet was + 12 ft., the crest of the glacis at the spot to be fired over + 4 ft., the ditch − 16 ft., the depth of the water about 4 ft., so that the surface of it might be taken at − 12 ft. Also, the ditch was 30 ft. broad, and had in the middle a cunette 5 ft. deep. The distance of the crest of the glacis from the counterscarp was about 15 paces; therefore from this crest to the face of the scarp wall to be breached there was a distance of 45 paces. The masonry work of the escarp consisted of rectangular blocks of red sandstone, about 9 ins. long and 6 ins. broad, and was 4 ft. thick at the top and 6 ft. at the

bottom, the whole being in good order. The angle at which the line of fire from Battery No. 8 met the face of the wall to be breached was about 55°, and consequently slightly less than 60°, hitherto considered the least admissible angle for oblique fire. This fact was considered unfavourable, especially as the charge to be used was smaller, and the velocity of the shot would be consequently reduced. Great fears were therefore entertained lest the shot should glance off the uninjured masonry; but any alteration of the position of the battery which perhaps might have given a better line of fire would have been attended by many disadvantages; hence, as the number of degrees below the least admissible angle was very small, it was resolved to adhere to the Battery No. 8. A further advantage was thus obtained—viz., that by adopting this oblique line of fire the distance was augmented between the spot where the line of fire cut the crest of the glacis, and the escarp; and thus the employment of a smaller angle of incidence was possible. This distance measured in the line of fire was 50 paces, the difference in level 14 ft., being the height of the crest of the glacis above the spot (— 10), 2 ft. above the water surface, where it was proposed to cut the line. 1·874 lbs. was about the right charge for this distance of 833 yds. from the battery to the crest of the glacis, and the angle of incidence $7\frac{12}{16}°$.

The task of first attempting breaching by indirect fire on active service, was by no means easy; and on account of the deductions which would be drawn from the success or failure of this first attempt, it was imperative to make every effort. The breach was to be formed in the right face, about 60 ft. from the salient of the work, at which point the full pressure of the earth of the superincumbent parapet was bearing; further, this spot was between two traverses in the covered way through which it would be convenient to fire. The breadth of the breach was to be about 60 ft., the variation of the point of aim from left to right about 48 ft., taken at right angles to the range; and since the distance of the left end of the breach was about 36 ft. further from the battery than the right end, the elevation from right to left had to be raised slightly in proportion.

The breaching began from No. 8 Battery, commanded by Captain Müller, on September 14th, at 7 a.m. After a few shots against the parapet in the salient of the work with maximum charges, the distance was ascertained to be 1050 paces; firing was then carried on against the highest visible parts of the parapet with 1·87 lbs. charge, after which the mean point of impact was lowered as much as necessary.

The observations of the effect of the firing were made from a trench conveniently situated between the second and third parallels; whence the glacis was perfectly in view, but not the face of the scarp to be breached. Observations from any more advanced part of the attacking works were not possible, on account of the rebounding of the pieces of shell and splinters of stones, which even compelled the position of the besiegers' works affected by them to be altered. One of several pioneers who, contrary to orders, passed this spot, was killed by a splinter.

The trial practice was greatly hindered by the fact of there being no

telegraphic communication between the range party and the battery; so that after the effect of each shot had been ascertained, the necessary correction had to be sent back through a chain of sentries posted in the trenches. This, of course, retarded the firing considerably. The elevation finally fixed by the trial shots was $7\frac{2}{16}°$. It varied according to the weather (frequently very stormy), some 16th part of a degree. It must also be added that in this as well as in the after processes of breaching, the elevation was not fixed so that the mean point of impact should coincide with the point to be hit; it was rather sought to raise it a height above this point equal to the mean vertical deviation of the shots, so that the greater portion of the area covered by the trajectories of the shot might be above the crest of the covering mass, which was at the same time no impediment to the ultimate object in view. Regulating the quadrant also presented difficulties, as important faults were discovered in connection with it which had to be corrected.

The trial shots were only concluded by mid-day September 14th, and then the formation of the horizontal cutting was commenced. On account of the difficulty of making first impressions on the wall by single shot, two salvoes were fired from the four pieces with the same aim, then a third salvo was fired at a spot distant 3 ft. laterally, where the wall was already shaken by the previous round, and each succeeding salvo at similar distances. Thus holes were cut in the wall up to the left end of the proposed horizontal cutting, the total alteration of elevation being $\frac{10}{16}°$; a series of rounds was then fired on the same line from left to right, and so on.

When this cutting had been about half finished, the news arrived that a mine, commenced in the third parallel to search for a countermine gallery, supposed to exist in front of the salient of Lunette 53, was finished, and communication with that gallery established. From the entrance to this gallery in the counterscarp, the face of the work could be completely overlooked, and thus the progress of the breaching observed minutely. It was ascertained that the lowest shot marks were accurate (1 to 2 ft. above the water line); that the facing of the part of the wall under fire, in consequence of the great dispersion of the shot, was destroyed up to a great height; and that shot hitting the intact masonry obliquely, glanced, or only damaged the face of the stonework very slightly; whereas favourably hitting shot caused great showers of large stones, splinters, and pieces of shell.

During the night of September 14–15, the crowning of the glacis was to take place, and it was settled that the part of the crown works falling in the line of fire should not be immediately thrown up; but the excessive eagerness of the engineers in charge did not allow this arrangement to be carried out, and on the morning of the next day, September 5th, on opening fire the unpleasant fact was discovered that the crown works on the glacis had been thrown up all along, and that the crest of the parapet was thus raised 2 ft. higher, immediately in the line of fire; so that with the charge and elevation which had been calculated and laid down, it was impossible to reach the line of the cutting. Any alterations in the existing arrangements would have caused great inconvenience and delay; it was therefore decided to con-

tinue with the same charge and elevation, firing at and demolishing the impediment the engineers had placed. But in accomplishing this object some 120 rounds were expended, which were therefore lost for the purposes of the siege.

During the after process of breaching, the cutting of the horizontal could not be accurately carried out, as laid down; for, on account of the dispersion of the shot, the wall fell in parts, followed by the earth it supported. This had the disadvantage of acting as a screen to the wall, the effect of shell exploding on the latter being thus considerably diminished. The formation of vertical cuttings, however, was no longer indispensable; it was only necessary to aim gradually higher to bring down the upper part of the wall entirely. Shots fired into the earthwork still remaining, with a charge of 2·645 lbs., brought down sufficient to cover over and smooth the roadway of the breach, about half the thickness of the original parapet being still left; and the breach—of which the slope was about 35°—was only practicable up to this remaining wedge. However, further firing made it more so, and it would eventually have been quite completed by No. 42 Battery, which had in the meantime been built and armed with six short (15 c.m.) guns, had not Lunette No. 53 been found deserted by the enemy when reconnoitred on the night of September 20th.

This inner part of the parapet, with a steep slope several feet high, being left standing, as seen above, proved very useful now for the quicker formation of a lodgment.

It was found that the dimensions already obtained from plans and calculations were very nearly accurate.

The breaching lasted four days—from the 14th to the 17th September inclusive. Firing continued from 7 a.m. to 7 p.m. Each piece expended from 50 to 70 rounds daily; so altogether about 1000 rounds were necessary for the formation of the breach. Unfavourable weather, and irregularities, from want of practice in serving the guns, very materially increased the difficulties of the task.

Breaching the Right Face of Bastion No. 11.

The taking of Lunette No. 53 was followed on the night of Sept. 21–2 by that of Lunette No. 52; and thus was obtained the command of those outworks from which the engineers' advanced works could be pushed on against the main object of the attack—Bastion No. 11. Up to this point of the siege, the artillery had been generally a little ahead of the engineers in their respective parts of the work of attack; and the former lost no time in commencing this, the most important part of their task—viz., the formation of a breach in Bastion No. 11, through which the fortress was to be entered; and as early as September 28th, fire was again opened.

It was found necessary to approach nearer the Bastions Nos. 11 and 12, and to increase the direct fire on them and their outworks; and for this purpose No. 42 Battery was thrown up on the night of Sept. 13–14

by Captain von Podewitz, 2nd Company of Artillery of the Guard, between the first and second parallels, close behind the so-called churchyard communication, and due east of the churchyard itself, and was armed with six short 15 c.m. guns. This position was chosen with a view to the ultimate breaching of Bastion No. 11; and so as to give a higher and more favourable position to the battery, an order was issued that the terreplein should only be lowered 2 ft. From the 14th to the 21st September this battery fired ordinary shell with considerable success against the above-mentioned works, and on the 23rd they resumed their work as a breaching battery, firing long shells (*lang granaten*), on which date also Captain Müller was again placed in command.

Of the structure and proportions of the profile of the Bastion No. 11 and its covered way, the following facts were known :—This bastion, in common with all those on the west front, had, through the conservation of the old Faussebraie, two lines of defence. The high line—called by the French "cavalier"—was merely an earthwork, separated by a rampart 18 ft. wide from the lower line of fire, which latter was a parapet duly revetted, &c.

Taking the "cordon" of this revetment at ± 0, the bottom of the ditch was -26 ft. There was consequently 26 ft. of masonry, 5 ft. thick at the top and 12 ft. at the foot, with 18 ft. buttresses. In other respects it had nothing particular about it. It was built of ordinary bricks, with a coping of squares of red sandstone. Immediately in rear of this coping lay the lower parapet, only 18 ft. thick. The relief of the cavalier was about $+ 15$. Under these circumstances, the object in view was naturally the overthrow of the lower parapet.

The ditch was over 100 ft. wide, having a cunette from 4 to 5 ft. deep, and might have been filled, had the war been prolonged, to a depth, including the cunette, of from 10 to 11 ft., making the water surface about ($- 20$).

As a rule, the figures estimated as above were found correct, with the exception of the ditch, and consequently the water surface, the former being 2 ft. deeper than assumed.

In front of Bastion No. 11 was the Counterguard No. 11*b*, made to cover the revetment wall of the lower parapet. Nevertheless, its height was not quite sufficient to effect this object completely, a strip of masonry about 4 or 5 ft. high being plainly visible from the breaching battery.

The crest of the counterguard over which it was necessary to fire was about 50 paces from the escarp, and taking the point to be hit at $- 18$ (2 ft. above the surface of water), the necessary angle of incidence was $4\frac{1}{2}°$, which for the distance—875 yds.—between the counterguard and the parapet, required a corresponding charge of 2·867 lbs. The line of fire of Battery No. 42 (which, as already mentioned, was intended for breaching Bastion No. 11), made an angle of 80° with the wall to be breached. The conditions were thus, on the whole, very favourable. The terminal velocities of the projectiles were about 685 ft., and at that distance and with the above charge the penetration of the projectiles was very great.

To prevent any interference with the engineers' advanced works,

the breach had to be made near the salient of the bastion, commencing at 30 ft. from this point; it was to be 90 ft. in breadth.

The process of breaching commenced on the morning of Sept. 23rd, at 7 o'clock. The day being fine and clear, favoured the practice greatly.

The battery—which was in open, and on rather high ground—received at first a rather brisk fire of Chassepôts from several of the enemy's works, notably from the counterguard of Bastion No. 11, on which many riflemen were posted behind solid sand-bag embrasures; but the first shells which fell on the escarp of the bastion caused such showers of stones and splinters to fly back against the reverse of the counterguard, that the enemy's fire ceased immediately, and was never renewed —a result which had been foreseen.

Before the breaching proper began, the battery fired trial shots, thus:—They commenced against the visible exterior slope of the parapet of the counterguard, raising the point of aim from the lower to the upper part of the slope, until the projectiles cleared the crest and fell on the scarp wall in rear, at which point the elevation stood at from $4\frac{6}{16}^\circ$ to $4\frac{7}{16}^\circ$.

They, however, tested the firing several times daily, by diminishing the elevation $\frac{1}{16}^\circ$ or $\frac{2}{16}^\circ$, so as to be certain that the greater number of the shots just cleared the crest; and it was found that, even with that slight diminution of elevation, instead of one or two only, three, four, or five shots struck it.

As they had six guns at their disposal, they altered the method adopted in firing against Lunette No. 53, and three guns fired from the right of the horizontal cutting to the centre, simultaneously with three others firing from the centre to the left; and as there was no fear of the shot ricochetting, the masonry having, moreover, less power of resistance, there was no necessity to fire at a spot where the masonry had been shaken by a previous round; but having fired a salvo at one spot, the succeeding salvo was fired at a spot $\frac{2}{16}^\circ = 5$ ft. on one side of it, and so on, each half-battery firing at its own half of the cutting, a second series of rounds being fired at the intervals between the holes thus formed. The observations of the effect of the firing were noted from the battery chiefly with the naked eye. There was a nearer point of observation in Lunette No. 53 (already taken), but it did not offer sufficient advantages to counteract the disadvantage of the fire of Chassepôts to which it was exposed. Although the shots dropped rather low, after passing over the counterguard, one could judge of the effect by the appearance of the explosion.

Firing was discontinued during night time. On the second morning —that of September 24th—when altogether about 70 rounds had been fired from each piece, signs were already observed characterising the rupture of the wall; and about mid-day, when 80 rounds had been fired, it was concluded that the horizontal cannelure had been completely cut, and that the formation of the vertical cuttings was advisable, each of which was made by one half-battery in the following manner:—After firing three salvoes at one spot, the point of aim was raised 5 ft. In about half-an-hour the masonry of about two-thirds the breadth of the

breach fell, from the right end of it. This was realised by the sudden disappearance of the visible wall, and part of its superincumbent earthwork, followed by a great splashing in the water of the ditch; and three more rounds fired against the left vertical brought down the remainder, but leaving the earth—which was of a clayey nature—standing. All six pieces were now directed against the right of the breach, firing in salvoes, so that the simultaneous explosion of the shells might cause a greater shaking of the earth. The elevation was fixed so that the lowest falling shot might be 4 or 5 ft. above the horizontal cutting already made, and the fire was continued so as to form a second horizontal cutting in the earthwork. Soon a partial fall of the earth was observed; but the further demolition had to be counter-ordered for the time, as the approaches were not yet nearly sufficiently advanced to undertake the storming of the breach. It was therefore feared lest the now already practicable breach might be isolated by the defenders, or in some other manner rendered impracticable.

The crowning of the glacis of the Counterguard No. 11*b* was only completed on the morning of the 27th September, when the demolition of the remaining earth would have been permitted; but on the afternoon of the 27th, at 5 o'clock, the hoisting of the white flag on the Cathedral of Strasbourg rendered this unnecessary.

The process of breaching this right face of Bastion No. 11 lasted, therefore, 18 hours. The number of rounds was about 600, making six or seven shot per linear foot. Competent judges must consider this a good performance.

Breaching the Left Face of Bastion No. 12.

In order to exercise greater pressure on the Commandant of the hostile forces, as well as to take the opportunity for further experiments in indirect breaching, the idea was mooted by the officer commanding the siege artillery and sanctioned by the Commander-in-Chief, of also making a breach in the left face of Bastion No. 12, although it was not originally intended to enter the fortress at this point. The proportions of the profile of Bastion No. 12 were similar to those of Bastion No. 11, only there was no second line of fire. The scarp wall to be breached was of bricks, and was supposed to be contiguous to the parapet in rear. The measurements of the ditch, and depth, &c., of the water, were also the same.

In order to obtain the most favourable conditions, it was decided to make the breach near the shoulder of the bastion, and to direct the line of fire along the ditch in front of the right face of Ravelin No. 50, which line, produced backwards, extended over the left face of Counterguard No. 51, and nearly over the salient of Lunette No. 53. At the spot where it cut the third parallel, the 5th Company of Garrison Artillery of the Guard (Captain Mogilowski) made, in the night of September 23–4, the Breaching Battery No. 58, close to Battery No. 45. It was armed with four short 15 c.m. guns.

The command was at first given to Captain Müller; but being

ordered elsewhere, he gave over the command to Captain Mogilowski. The distance was about 790 yds., and the line of fire was perpendicular to the face of the wall.

On account of the great distance of the counterguard from the scarp —200 paces (150 m.)—and other circumstances, the foot of the wall could be hit when using the maximum charge of 3·3 lbs.; but as with the consequent low trajectory the engineers' works and Lunette No. 53 would have been in danger, a smaller charge of 2·645 lbs.—afterwards 2·867 lbs.—was used. The elevation was $3\frac{9}{16}°$, and the angle of incidence $3\frac{14}{16}°$. The penetration of the 15 c.m. gun at this distance was very good, and the terminal velocity of the shot about 665 ft.

The breadth of the breach was limited by the breadth of the ditch, along which the battery fired, and had to be further lessened in order to avoid the glancing of shot against the revetments of the ditch. In order to take every possible advantage, it was settled that the pieces should fire crosswise; that the two pieces on the right should cut the left half of the cutting, and *vice versâ*. By this means the probable breadth of the breach would be from 36 to 40 ft. Firing commenced at 7 o'clock in the morning of September 24th (the breaching battery against Bastion No. 11 being still in action), and continued daily till 7 p.m., only long shells (*lang granaten*) being used.

The weather was very favourable, but as they could not see Bastion No. 12 from the battery, the fixing of the elevation required special precautions. Observations were made from the salient of Lunette No. 53—the only point from which any part of the masonry, and then only the cordon near the shoulder of Bastion No. 12, could be seen.

The trial shots were made against the part of the parapet immediately above the spot proposed for the breach; the point of aim was then lowered, first to the masonry mentioned as visible, and then to the proposed right end of the horizontal cutting. After a few rounds, it was recognised by the splashing of the water that the shots were going too low. A slight alteration of the elevation remedied this, which brought it to $3\frac{9}{16}°$.

Nos. 1 and 2 guns fired from the left end of the cutting, and 3 and 4 from the right end, towards the centre and back again, and so on. After firing one salvo at one spot, they altered the point of aim 5 ft. laterally.

Any observation was very difficult, and the practice much retarded by the want of proper communication between the observers and the battery. This was especially felt during the trial shots, which took several hours. Next day—25th Sept.—at 7 p.m., after 359 rounds had been fired, the usual signs appeared, showing that the horizontal cutting had been formed. Thereupon, at 8 a.m. on the 26th Sept., firing two guns at a time, the vertical cuttings were commenced and formed in three hours, with an expenditure of 106 rounds.

The disappearance of the visible part of the scarp, and part of the earthwork above it, left no doubt as to the destruction of the wall. The complete demolition of the earth was deferred for the same reason as in the case of the other breach.

A total of 465 shots were necessary for the formation of this breach.

After the surrender, it was found that the earth remained standing

perpendicularly, and that behind the wall were two supporting arches of masonry. It was further discovered that the vertical cuttings in both breaches had been made with great precision; testifying to the remarkable accuracy of the 15 c.m. guns.

The Chief Engineer, General-Major v. Mertens, was asked to report upon the state of the breaches, which he did as follows:—

"The breach of Lunette No. 53, with a little levelling, and that in No. 11 Bastion, were quite practicable; the one in Bastion No. 12 remained unfinished."

As to this latter, it may be repeated that it was formed only for the sake of practice for the artillery, and from the commencement had not been intended to be used in any assault.

Though this pamphlet was only intended to give a few observations on the use of indirect fire at the siege of Strasbourg, we may in conclusion add the two following facts, which may be certainly deduced from the above exposition:—

1. That the breaching facilitated greater rapidity in the engineers' work.

2. That this premature breaching had considerable influence in causing the garrison to decide on capitulating.

On September 20th, the scarp wall of Bastion No. 11 had fallen; and on the 25th, that in Bastion No. 12. The morning of the 27th had been fixed for a descent into the ditch, and on the afternoon of that day the capitulation took place.

General Ulrich said, in the commencement of his proclamation to the inhabitants of the town, on September 27th:—

"I have to-day discovered that the defence of the town is no longer possible; in which opinion the Committee of Defence unanimously agree. I must therefore be under the sad necessity of negociating with the commander of the besieging army," &c.

He further wrote, in a letter to his cousin, dated Oct. 14th, 1870:—

"My Committee of Defence, in answer to my questions, after deliberating, said we could not resist the storming with any chance of success; so that the moment for capitulation had arrived."

From this it is clear that an assault was expected by the garrison; thereby shewing that they themselves considered one possible. But assault on such a fortress is out of the question, unless practicable breaches are formed. Hence it follows that breaches quickly formed contribute mainly to the speedy fall of a place.

The object would have been much retarded had direct fire been employed; indeed such fire could not have been commenced until September 29th or 30th, during which time numberless other difficulties would have arisen, which, however, lie beyond the limits of this pamphlet.

v. DECKER,

General-Lieutenant, and Inspector of the 1st Artillery Inspection.

EXTRACTS

FROM THE

"AUSTRIAN MILITARY JOURNAL,"

FOR JANUARY, 1874.

BY

LIEUT. J. J. CONGDON, R.A.

The first number of the "Austrian Military Journal" of the present year contains an interesting article by Major Hotze, on the "Theoretical Study of Tactics by Officers during the Winter." The author says the objects of such study are:—1st, that officers should learn something new; 2nd, that they should be convinced of what they have learnt, and discover new points for consideration. These objects are not altogether practically attained, he says, in the instructions laid down for German infantry and cavalry; and principally because many officers do not work out the problems for themselves—that is, they do not think them out. It is not necessary to go deeply into the subject of how far this dependence on the conclusions of others exists, but it does exist. Some of the senior captains conscientiously strive to obtain by some means the solution of a problem; but unfortunately only in order that they may act up to the letter of the instructions, and shirk further trouble in the matter. It appears, according to Rule 271 of the "Instructions for Infantry," exemption is awarded as a reward for the good solution of one of the problems; and as those captains who are still obliged to furnish proofs of their work feel themselves kept in the background, it is the custom to grant this exemption to at least the three senior captains of each regiment. Thus this system appears to be somewhat vexatious. It is hard to understand why captains of infantry and cavalry, and still younger officers who have passed through the military college, should be exempted from exercises which are of great advantage, even to the most competent, while well-experienced generals are practised in the leadership of troops and tactics.

Years before many of the captains have done the infantry course, they are exempted from the manuscript tactical exercises; and when a transfer

takes place, the new commandant is bound to respect the exemption once given to an officer, and so he is deprived of a very important means of forming an opinion of the capacities of the new-comer.

But even if all these evasions did not take place, one could not expect a really practical result from the work; for the qualifying for exemption by the solution of a tactical problem is easily performed in a few weeks.

What makes an apparently easy tactical task difficult, is the promptitude which must be exercised in cases of emergency, both in resolving upon a line of action and in carrying it out. In fact, it may be said that the solution of a tactical difficulty without limiting the time is almost useless—that, at least, it gives no correct idea of the capacity or knowledge of the solver.

Still less do the officers make sketches for themselves, but copy them from others. For illustrating the situation of the troops at decisive moments, it is only necessary to sketch them on a piece of paper of the same size as the map furnished. The surveying and sketching of a piece of ground is a branch of education of itself, and must be altogether separated from tactical exercises. In war, one never has a better guide to go by than a special map of the district, and this is therefore recommended for use in tactical problems. The following is suggested as an improvement on the present system:—

1. The problem should not be known beforehand, and when given out should be immediately solved. Thus officers would have to be well versed in the theory, for they would not know what kind of test to expect—whether they were to be examined in duties of precaution, bush-fighting, reconnaissance, &c. The solutions of the questions would then give a correct notion of the knowledge of the officers.

2. The work should be performed in the presence of the examiner. The difficulty of tactics is the application; and what makes the application difficult is the shortness of the time allowed for the recognition and consideration of the circumstances, and for the issue or comprehension of orders.

To decide quickly on a reasonable and feasible step, and to carry out well whatever is resolved upon, is the main point; and if a man does what is necessary, and takes only half-an-hour about it, he may well be called a better tactician than another who produces a more elaborate solution, but takes several days to work it out.

Though everyone has not the talent of quick perception and comprehension, still it is possible for everyone to improve in these qualities.

The advantage of having the work done under supervision, is the certainty of obtaining the examinee's own production. By such a procedure it would not be necessary for staff officers to set so many small problems—a task more difficult than is generally allowed; and if several officers were to work out the same problem together, there would be this great advantage—that they would derive profit from the discussion which it would bring with it. "How did you do this or that?" is not an uncommon question at the close of an examination.

3. The situation, or data of the problem, should be a plausible one, and sufficiently clearly defined for the examinee to realise it thoroughly.

Sometimes the given situation renders the possibility of a good solution questionable.

4. No more information should be given relative to the enemy, the ground, and other circumstances, than could be known in the field under similar conditions. According to the present instructions, the strength of the forces on both sides is given. Such a system is apt to spread the doctrine of numerical superiority, which is a damper on the spirit of military enterprise. Instead of given instances from military history of how seldom one side have known the strength of the other; how that the strength of the enemy is almost always overrated; and of how generally it is not the consciousness of numerical superiority, but a determined will which incites to action and secures the victory, it is assumed as an axiom that the side which has the numerically strongest force is the one entitled to victory.

But in practice one seldom can do more than judge approximately of the strength of the enemy, and yet one must act upon the estimate.

For example:—A column receives orders to eject a hostile force from the Park of Erlaa. (*Vide* map in Journal). Who numbers the defenders under the circumstances given in the example? (*Vide* Ex. 1 of present chapter in Journal). The attacking cavalry are repulsed by the small-arm fire of the defenders at some 400 paces distance. Whether the defending force consists of one half-battalion or four, how would it be possible to discover?

Major A. has received orders to drive the enemy out of the park, and a certain force is at his disposal. That is sufficient; and now let him use all his discretion and power in carrying out the order given him.

It is the opinion of the author that a very evil influence is exerted upon the training of officers, if it be the rule to place at the disposal of those who have to carry out an offensive operation more troops than their adversaries; not only because they are thus taught to yield to numerical superiority, but also because an entirely erroneous picture of war is thereby given; for in war comparatively little is known of the circumstances of the enemy, and the little which one fancies one knows often turns out afterwards to be incorrect. Moreover, even what was the case ten minutes before, may, at the critical moment, be entirely changed.

5. The problem should be strictly in the form of an order; and the order should be made out exactly as, under the supposed circumstances, it would in reality be delivered (verbally or in writing).

The ear of the young officer should be accustomed to a precise and well-turned delivery of orders.

In order to complete as far as possible the copy of reality, such an order must often contain conditions which have but little to do with the actual solution of the problem—as in Ex. 1 (noticed above), the idea of converting the Castle of Erlaa into a field hospital, &c.

6. Under the title "object of the operations," should be described what points are to be considered in the solution of the problem.

It would be, perhaps, as well to limit the exercises to the following points:—

(*a*) A short but graphic estimate of the ground. The officer should

place himself in the position of a reconnoiterer who has just ridden over the ground in question. The result would be, the description would generally be modified according to the object with which the reconnaissance was undertaken. For instance, a person who reconnoitres the approaches of a village in order to find out the best encamping ground for a brigade, must treat it from a different point of view from another who reconnoitres it with the object of putting the village in a state of defence, or of attacking it.

(*b*) A short exposition of the leading idea of the operations.

(*c*) The disposition should be given *verbatim*, as it would have to be given in real war (verbally or in writing). The disposition is the incorporation of the leading idea. The question is simply whether the disposition meets the object in view, and whether it expresses rightly the line of action determined upon—whether, in fact, the officer is so practised in the technicality and style of orders as to give the directions which he intends to give; in other words, whether he expresses himself correctly, and in such a manner that he may not in any human probability be otherwise understood than he intends to be, in order that the responsibility of a misunderstanding may not rest upon him. The disposition should begin with communicating to commanding officers what has been learnt about the enemy, what operations have to be carried out, and on what general plan it is proposed to proceed. Then should follow the order for the carrying out of the first necessary steps, but no more. Here one is liable to meet with a very widespread evil among Germans—namely, long-winded dispositions which seek to lay down and prescribe beforehand every movement up to the end, which naturally all the more engenders uncertainty and confusion. With regard to this, it should be borne in mind that nobody should interfere within the sphere of another's command. (Up to this, this point has only been partially observed). For instance, the commander of a battalion gives directions to a company to drive the enemy out of a wood. The disposition of the company for the attack—for example, the strength of the line of skirmishers, &c.—should be left entirely in the hands of the commander of the company. When the preparatory arrangement for the leading idea announces the first disposition, the problem is thereby solved; for in this first disposition lies the germ of the success or failure of the undertaking, the after part of which is difficult to carry out on paper.

What should, in addition, be required from the officer is—

(*d*) The graphic exposition of the situation of the troops at certain moments, as the result of the dispositions made. Whoever orders the movements of troops must constantly bear in mind the space which they thereby occupy.

* * * * * *

Here follows a comparison of this system with the present, and then nine examples are given, each of which would take about two hours to work out. There are six for captains of infantry and "riding-masters" (captains of cavalry), two for subaltern officers, and one for officers of the general staff. I have quoted at some length from this chapter, in order to give a fair explanation of the author's views. In conclusion, I would recommend anyone who takes a special interest in the subject to refer to pages 28 *et seq.* of the Journal, and with the aid of the map at the end work out the examples there given.

In the same number (p. 45) is an article on "Operations with Field Works."

The old sayings that the breast of the soldier is the "best protection," that the bullet is a "contemptible thing," are since 1866 quite exploded. Now-a-days, when every effort is made to obtain superiority over the enemy in *morale,* numbers, organisation, improvements, tactics, commissariat, and even in the clothing and supplying of boots; in employing the last man, the last horse, the whole range of science and industry for smoothening the way to victory, the help of fortifications will never again be despised. Field fortifications will be employed in future in every war—in every battle; and this is the author's reason for asking the question, "How will such warfare develop itself in the future?" The answer has an interest for all branches of the service, and if the author succeeds in giving a satisfactory one—which he doubtless does in the present article—we need no other argument to convince us of the merit of the paper. The author treats every case carefully, and in detail, in true German style; following the example of the great Moltke, who is reported to have once listened attentively to an officer at the military college whom he was examining, and when the latter had, as he thought, completely exhausted the subject, to have asked mildly, "What next"? "and next?" I was once told by a German professor, that nobody could discover so many points in any case as Moltke; and doubtless this is the secret of his great generalship.

From a paper on the reorganisation of the Russian imperial army, the following information with regard to the organisation of the Russian artillery is extracted:—

The Russian Royal Artillery is formed into brigades, and is divided into (1) foot or "driving" artillery, and (2) mounted artillery. The still existing reserve field and horse artillery will, by the new reform, be definitely classed in groups for service with depôt or local troops.

The artillery brigades form an integral part of those army-divisions to which they belong.

The foot artillery consists of 3 artillery brigades of guards, 4 of grenadiers, 40 of the line—total 47—divided amongst the army divisions. In addition to this, they have 2 Turkestan and 1 East Siberian distributed amongst the military districts, and 1 West Siberian battery. It is formed, then, omitting the last named battery, of 50 foot artillery brigades.

As we have already said, the foot artillery brigades in Central and Eastern Asia retain their old organisation. They could scarcely be applied to any practical purpose in a Europeam war, and may therefore be left out of the question.

According to the old rule, each artillery brigade consisted of 3 gun and 1 mitrailleur batteries; the 4 grenadier brigades, and those of the 19th, 20th, and 21st army divisions, had an additional 4-pr. gun battery each.

By the new rule, each foot artillery brigade is to consist of three 9-pr., two 4-pr., and one Gatling batteries. Each foot artillery brigade is therefore increased by two 9-pr. batteries; and the four grenadier brigades, and those of the 19th, 20th, and 21st army divisions, have each one 4-pr. battery less, which is changed into a 9-pr. battery. The grenadier brigade will, as

originally intended, supply the necessary mountain batteries for war in the Caucasus. Moreover, by the new organisation, the 4-pr. foot batteries, which were drawn by four horses, will have six horses in war time.

In each foot artillery brigade, Nos. 1, 2, and 3 batteries have 9-pr. guns (*i.e.*, 10·665 centimeters calibre). No. 6 is the mitrailleur battery.

All the gun batteries are armed with rifled breech-loaders, some of cast-steel, but mostly of bronze. They have different methods of closing the breech. Each battery has two divisions of four guns each, and these again are subdivided into sections of two guns each. It cannot yet be definitely said how many of the reserve batteries, which according to the old rule formed a fifth part of the war complement, will be reduced.

The war complement of the battery is as follows:—

9-pr. Foot Battery.—6 officers, 316 men, 214 horses, 8 guns, 24 ammunition wagons, and 9 park wagons.

4-pr. Foot Battery.—6 officers, 255 men, and—including 6 horses to a gun-team—180 horses, 8 guns, 16 ammunition wagons, 8 park wagons.

Gatling Battery.—6 officers, 215 men, 140 horses, 8 mitrailleurs, 8 ammunition wagons, 8 park wagons.

The strength of the non-combatants—*i.e.*, writers, professional men, train-soldiers, officers' servants, &c.—is in the 9-pr. batteries 37, in others 36.

Drivers and gunners in reserve amount to 75 for the 9-pr. batteries, 43 for the 4-pr. batteries, and 35 for the mitrailleur batteries.

The formation of the 94 new 9-pr. batteries will, as already said, follow in due course, and will probably be settled by the end of 1875. In the year 1873 thirty-five batteries were formed.

After the augmentation is completed, the total of the new batteries of the 47 foot artillery brigades will consist of the following, arranged according to calibre:—141 9-pr. gun batteries, with 1128 breech-loading guns; 94 4-pr. gun batteries, with 752 breech-loading guns; 47 11-millimeter Gatling batteries, with 376 mitrailleurs; grand total, 282 batteries, with 2256 guns, including 376 mitrailleurs.

The war complement of the entire foot artillery consists of 1,692 officers, 78,631 men, 53,684 horses, 2,256 guns, 5,264 ammunition wagons, 2,397 park wagons.

Omitting non-combatants and combatants in reserve, which amount in the aggregate to 26,555 men, the war complement of the whole of the artillery is 1,692 officers, 52,076 non-commissioned officers and men, and 2,256 guns.

The army in the Caucasus has 6 artillery brigades, with 36 batteries or 288 guns, including 48 mitrailleurs. Its total war complement is 216 officers, 10,038 men, 6,852 horses, 288 guns, 672 ammunition wagons, 300 park wagons; and it numbers, omitting non-combatants and combatants in reserve—which include 3,390 men—a fighting strength of 216 officers, 6,648 non-commissioned officers and soldiers, and 288 guns.

(*This is to be continued in another number of the Journal.*)

WOOLWICH,

3rd March, 1874.

COMPOUND GUNS, MANY-BARRELLED RIFLE BATTERIES, MACHINE GUNS, OR MITRAILLEURS.

BY

CAPTAIN J. F. OWEN, R.A.,

CAPTAIN INSTRUCTOR, ROYAL GUN FACTORIES.

PART I.

MEMO.

In accordance with Resolutions 3 and 4 of the Annual General Meeting, the Committee R.A. Institution request that Members who have not an account with Messrs. Cox and Co., will be so good as to notify to the Secretary how their subscription will be paid for the future, whether direct or through an Agent.

They also wish to point out that the price of "Kane's List" has been reduced, for the present, to 2s. 6d. for a bound, and 1s. for an unbound copy. Slips to complete the work can be obtained on application to the Secretary R.A.I.

by many artillery officers—especially those quartered abroad—while almost all read the papers of our R.A. Institution, I hope that the following brief account of machine guns, past and present, their uses and employment, will not be without interest to my brother gunners.‡

* Major Fosbery, V.C., Bengal Staff Corps, was urgent in bringing these weapons—the use of which he strongly advocated—to the notice of our Government. (*Vide* "Journal U.S.I.," No. LVI., for a paper of his on the subject).

† At the United Service Institution, London. (*Vide* Journal of that Institution, No. LXVI.)

‡ After a part of this paper had been written, an opportunity was given me of reading the report of a Swedo-Norwegian Commission on the subject of mitrailleurs. This report, which has been translated by Captain King-Harman, R.A., is of the most interesting nature, and will, I understand, be published as a translation to accompany "Proceedings, R.A. Institution." As the report contains a clear and succinct account of the mitrailleurs used by different nations, its publication may almost seem to render this paper superfluous. I have, however, thought it best to complete it, and to include in it much information obtained from the report in question, as also from a subsequent paper in the "Revue d'Artillerie" for February, 1874.

Fire-arms having many barrels, intended either to be fired together or in rapid succession, are by no means a modern conception; although the introduction of rifling and metallic cartridges has of course revolutionised their nature and manufacture.

In the earliest days of artillery, we find machines used under the names of ribaudequins, orgues,* orgels, organ or tube guns, &c., in which several barrels of small calibre were united in a single mass, or on a rigid framework.

For the protection of fortresses, such guns were employed in Flanders in 1347; four breech-loading tubes of small calibre being placed on a two-wheeled cart, with their muzzles protruding through a wooden screen, protected by a *chevaux-de-frise*.†

Andrea Cattaro mentions a machine used in Italy in the 14th century‡ (against the people of Carrara), which consisted of a carriage having 144 small bombards (*bombardelles*) ranged in rows of 12, three of which rows could be fired at once, and so 36 balls (about the size of an egg) discharged at a time. The carriage was drawn by four horses, and three men were sufficient for loading and firing the 144 bombardelles.

At the battle of Tongres, again, in the year 1408, a number of ribaudequins, or tube guns, were used, but apparently with little effect; and three years later we find that the Duke of Burgundy's army of 40,000 men had 2000 organ guns, besides cannon.§

These weapons were originally of clumsy construction, and could not be discharged with rapidity. Towards the end of the 15th century, however, more efficient organ guns were taken into the field,"‖ but wheeled carriages, strong enough to resist the recoil of a field piece, and yet fairly mobile, were constructed about this period; so that Francis I., when invading Italy in 1515, though he carried organ guns with him, also took a number of field pieces. As the latter improved in mobility, the use of tube guns was gradually given up, and after the 16th century their employment in war seems to have been exceptional.

Ufano, indeed, writing in 1621,¶ gives a drawing of a four-tubed gun mounted on a field carriage as a weapon then in use, and we find similar machine guns employed by the Scotch in 1644, during our civil war. At the battle of Copredy Bridge, fought in that year, the Cavaliers captured "two barricadoes of wood, which were drawn upon

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* M. Remi ("Memoires de l'Artillerie,") defines an orgue as "a machine composed of several musquet barrels fastened together, and used for the defence of breaches and entrenchments, on account of the possibility of firing from them several shots at once."

† Citadella's description quoted by Chesney ("Observations on Fire-arms," p. 57). Models of such guns may be seen at the R.M. Repository, Woolwich.

‡ "Ancient Cannon in Europe," by Captain H. Brackenbury. ("Proceedings R.A. Institution," Vol. V., p. 33).

§ "Etudes sur l'avenir de l'Artillerie," by the Emperor Napoleon III.

‖ Specimens of such weapons exist in Germany—*e.g.*, Weigel, describing in 1698 the contents of the arsenal at Nuremburg, mentions tube guns with 33 barrels, termed "Todten-orgels," on account of their deadly effect.—"Ancient Cannon in Europe," by Captain H. Brackenbury, R.A., ("Proceedings R.A. Institution," Vol. V., p. 29).

¶ "Artillerie," par Diego Ufano. Zutphen, 1621. Plate *β*, opp. Chap. xxiii.

wheels, and in each seven small brass and leather cannon charged with case."*

For some two centuries from that date, we hear little more of many-barrelled guns, until the Crimean War woke up the spirit of destructive invention. The science of mechanism had made gigantic strides since the 17th century, and although metallic cartridges were not yet used, rifling had come into vogue.

In 1853, Mr. S. A. Goddard invented a rifle battery of 36 barrels, combined together and mounted on wheels. Later on, Sir J. Scott Lillie and others brought to the notice of Government several natures of compound guns, on frames or wheels. None of these inventions were considered applicable for general service, nor was it until the great Secession War in America of 1860 that machine guns were again used in the field.

An engine of war, called a Requa rifle battery, was employed at the siege of Charleston. It consisted of 25 rifled barrels, each 2 ft. long, arranged horizontally on an iron frame upon a field carriage, and it weighed altogether about 1400 lbs. It could fire at the rate of 175 shots per minute.†

General Gilmore, commanding U.S. forces, reported with regard to this weapon:—"I feel quite satisfied that it is adapted to the defence of earthworks, particularly in a flat country like this, where the horizontal line of dispersion afforded by the fire of this piece is more effective than the cone of dispersion of the howitzer."

Notwithstanding this report, they did not come into favour, and machine guns, somewhat resembling the Gatling, exhibited to General M'Clellan (when before Richmond, in 1862) were contemptuously called "coffee grinders," and never brought to the front. Their mechanism was still imperfect, while the wooded country in which most of the fighting took place was not suited for their employment. Otherwise, the Americans would certainly have made more use of them in that war—a war in which, as Rossel says, "each new means was tried, every old one had its turn; where, as soon as an operation of war was known and appreciated, its use was pushed to an extreme."‡

Subsequently to 1860, many new machine guns were brought to the notice of our War Office—*e.g.*, those of Colonel Martin, 4th King's Own, in 1860; of Mr. Palmer, U.S., and General Vandenburgh, also an American, in 1862-3; of Mr. Dupuis, and Captain Warlow, R.A., in 1866. Though some were ingenious, none of these machines were worth much experiment.

In 1869, the question of such weapons was seriously taken up by different nations. The United States Government ordered 100 Gatling guns, to be used for flank defences, and occasionally as field artillery;

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* Clarendon, p. 522, quoted by Lieut. Hime, R.A., in his "Field Artillery of the Great Rebellion." ("Proceedings R.A. Institution," Vol. VI., p. 301).

The nature of tube was no doubt copied from the leather and brass field guns employed by Gustavus Adolphus, under whom many Scotchmen fought in the Thirty Years' War.

† For a full description of this weapon, *vide* Owen's "Modern Artillery," p. 296.

‡ The "Art of War," by L. N. Rossel, Captain of Engineers.

while several European states had one or two Montigny mitrailleurs manufactured for trial.*

In 1867, our Ordnance Select Committee tried a Gatling gun against a 9-pr. R.B.L. gun, with very fair results for the former; while in 1869, as Major Fosbery had reported favourably to the India Office upon the Montigny, and the French Government were making a similar weapon in considerable numbers, it was decided to carry out further trials, both with the Montigny and the Gatling gun, which latter had been much improved by Mr. Broadwell since the experiments of 1869.†

In August, 1870, a Special Committee carried out these further trials, which resulted in the preference being given to the Gatling gun, a small number of which the Committee recommended should be at once purchased.

Their report was made in November, 1870, at which date a full knowledge had not been obtained of the effects of the mitrailleurs used in the Franco-German war of that year. Twelve Gatling guns, however, of small calibre, for land service, and 24 of medium, together with 12 of small size, for sea service, were ordered as a tentative measure, until further experience was gained.

In November, 1871, the Special Committee above mentioned having prosecuted further enquiry as to the intentions of foreign Governments regarding machine guns, and having examined a number of officers who were present with French or German armies during the war, made a second report, in which they adhered to their former opinion, recommending the adoption of the larger Gatling gun of 0·65-in. bore for coast defences and naval service, and the smaller of 0·45-in. calibre for field purposes.

As already mentioned, a small number of these guns had been ordered in 1870, and it was thought advisable, before manufacturing any more, that these should be thoroughly tried in the service.

This course seems to have been a wise one; for according to the report of the Swedo-Norwegian Commission upon Mitrailleurs, which is dated November, 1872, a machine gun superior in almost every particular to our service Gatling has been invented by certain Swedish patentees.‡

Having run briefly through the history of the compound and machine

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* In 1867, our military *attaché* at Paris forwarded a battery gun invented by a Mr. Mouceux, consisting of 21 barrels, in three tiers. This was inferior to the Gatling and Palmer guns. In the same year, Her Majesty's minister at Brussels called attention to the manufacture of the Montigny mitrailleurs. In 1868, also, a rifle battery, invented by Colonel Claxton, was submitted for trial. This consisted of 8, 10, or 20 barrels, to be fired by pairs. It did not appear so good an arm as the Montigny.

† Between July and November 1870, numerous inventions, or supposed inventions, were submitted for trial, but were found much inferior to the Gatling. Some of these conceptions were rather extravagant—*e.g.*, one gentleman proposed a gun, to the muzzle of which was to be fixed a "spreader," resembling the "rose" of a garden hose. Through this small shot were to be discharged from the gun!

‡ Since this was written, further report on the mitrailleur in question has been made by a French Committee, who do not view it so favourably. (*Vide* p. 443).

guns of the past, and pointed out the various stages of enquiry which led to the introduction into our service (in 1870) of the few we possess, we come to the more interesting parts of our subject—viz., the employment of machine guns of the present day, the effects given by them in actual warfare, the reasons for and against their employment, and also the question of their tactical use, and the organisation necessary, should they be taken into the field.

Before discussing these, it will be necessary to say a few words as to the several natures of this weapon adopted by different nations.*

The French, as we know, employed mitrailleurs in 1870 in large numbers, having in their armament at the commencement of the war as many as 190 of these machine guns. Their mitrailleurs were of the Montigny type generally; though, as the war progressed, and more arms were required for the mobilised peasants brought into the field, other descriptions, made principally in America, were also used by them.† They still keep as service armament the so-called French mitrailleur pattern.

In Prussia, both Montigny and Gatling mitrailleurs were tried in the year 1869, in the presence of the King; but as it was thought that the results gained by their use were not adequate to "the *personnel* and *matériel* required in serving them," they were not approved of.

With the exception of one battery of revolver cannon on the Feldl system, made during the war,‡ no machine guns have been made for this power; but we must remember that large numbers of the French mitrailleurs captured in 1870 are in her possession. Some of these were tried, indeed, at Berlin, in 1871, and pronounced superior both to the Gatling and Montigny guns—an admirable conclusion to arrive at as far as economy is concerned, but one scarcely borne out by unprejudiced evidence.

Russia, in 1873, had as many as 300 Gatling guns, but since that date has adopted the Nobel machine gun—a species of Gatling, with certain alterations on the plan of General Gorloff.

The Swedo-Norwegian report, before quoted, states that these alterations are by no means improvements upon the original.

Austria has adopted the system of Christophe and Montigny in her mitrailleuses. She has added many of these weapons to her armament.

Turkey possesses a number of machine guns made, like our own, on the Gatling principle.

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* Every machine gun now made would probably be used for much the same ends, whatever the details of its construction; and as these details would somewhat encumber this part of the paper, and would affect but little the broad questions as to how and where such weapons should be employed, they have not been entered into here, but are given in Part II., which follows.

† Some Gatlings were used with General Chanzy's army, while the army of the north, under General Faidherbe, had a few Claxton guns. This difference in nature of machine guns used accounts for certain discrepancies in evidence.

‡ These are no longer in the Bavarian armament. (*Vide* "Revue de l'Artillerie," Tom. II., p. 515, September 1873).

America, as we have seen, also uses the Gatling—which, indeed, owes its origin to that country.*

In the kingdom of Sweden and Norway a Commission has lately investigated the subject, and according to their report a species of machine gun invented by Messrs. Winborg and Palmcrantz is likely to be adopted there. It seems to be superior in some points to any existing nature of this weapon.

A six-barrelled machine gun, termed the "Hotchkiss revolver cannon," has lately been experimented with in Germany. It is meant to fire small shells weighing, when full, about $1\frac{1}{2}$ lbs., with percussion fuze. It outwardly resembles a Gatling, but has only one lock, opposite to which each barrel is brought in turn.

EMPLOYMENT OF MACHINE GUNS, AND THEIR ADVANTAGES GENERALLY.

When a new invention, or an old one revived, is brought to public notice, we invariably find that on the one hand it is unduly extolled, and on the other decried, without much regard to its utility. Such was the case with the mitrailleur.

Some men—ardent inventors, as a rule—supposed that the introduction of the rifle battery gun would alter old conditions of attack and defence. As an example of this we may take the following passage, quoted by Major Fosbery, *à propos* of mitrailleurs :—"Power will no longer be exclusively on the side of the big battalions; but as machinery has rendered industry rich and prosperous, so now, whilst diminishing, or at least without increasing, a war expenditure, it is about to render small peoples and little states as powerful for defence as are the great for attack."

Mr. Gatling wrote a pamphlet about his gun, in which he urged its claims as compared with infantry. He considered it to be a means of revolutionising, in a great degree, the present modes of warfare. A few men, he stated, furnished with these death-dealing engines, would be able to defeat thousands armed with ordinary weapons, and consequently their use would in a great degree supersede the use of large armies.

This reminds one of the old picture in "Punch," where the soldiers of opposing forces amuse themselves with cards and dominoes, while automatic fire-arms thunder death and destruction at one another.

On the other hand, prior to 1870, many laughed at the very idea of using such weapons; and the Prussians, in particular, spoke slightingly of arms which they knew their probable antagonist, France, had largely adopted. While the Franco-German war lasted, it was almost necessary

* The Secretary of State for War has proposed to Congress this year (February 1874) that 200 additional Gatling guns be purchased, for flank defence of fortresses.

for the Prussian staff to decry their powers, and to disabuse the minds of their men of an exaggerated fear regarding the destructive effects of the mitrailleurs, which had been much vaunted by the French.

The experience, however, which was gained during the war of 1870, and careful official investigations made since that time by the War Departments of various powers, have cleared up the subject very much, and enable us now to form a fair estimate as to the value of machine guns, and to see more plainly the uses to which they should be applied.

We may say with some certainty that their employment will, in general, be restricted to the following :—

I. *For Field Service.*—An addition of a light nature in small numbers to the reserve artillery of an army, for increasing the fire of infantry at critical moments,* and for the *defence* of bridges, villages, field entrenchments, &c.

II. *For Fortresses or Siege Works.*—In caponnières, têtes du pont, breaches, and flank defence generally, and for use in advanced trenches.

III. *For Naval Purposes.*—Firing from ships' tops, and in boat operations.

To understand how these conclusions have been arrived at, we must take in detail the several modes of employment possible.

I.—Employment in the Field.

In the field, mitrailleurs would have to oppose either artillery, cavalry, or infantry.

To be effective against field guns they must have long range, be comparatively heavy, and carry such a weight of ammunition that the number of horses required would be almost the same as that used with a field gun; while for many purposes they would be quite powerless—for instance, against walls, stockades, entrenchments, or cover of almost any kind.

Against the horses and men of artillery exposed within their range such mitrailleurs might indeed be formidable; but that would not make up for their impotence in shell fire for destroying villages or *matériel*, blowing up ammunition wagons, driving troops out of cover, &c.

General Walker, who accompanied the Prussians, states that "the French mitrailleurs were invariably driven off the field the moment they showed themselves so that the Prussian artillery could get at them." (The best range for the Prussian guns was 1800 yds.)

Captain Gurdon, R.N., who was with the French army of the Loire, says that, when opposed to artillery, mitrailleurs always had the worst of it. He only saw one case when they had any effect upon the former—"at the battle of St. Jean-sur-Eroe, where three Prussian 12-prs. came down a road and opened fire upon us at a distance of 2400 yds. We

* As batteries of position would be used to strengthen fire of field guns.

brought four mitrailleurs against them, and after a quarter of an hour these guns limbered up, evidently having some of their horses and guns disabled, and retired another 300 yds. to the rear."*

The Special Committee (of which Colonel Wray was President), in their report of 1870, state:—"We are also impressed with the effect produced by the medium-sized Gatling—0·65-in. calibre—at long ranges, as compared with that of a field gun; but looking at the weight of ammunition required to produce this effect, and to the exceptional conditions under which the larger Gatling could be used with advantage in the field, we are satisfied that a gun is far preferable at long ranges, and consequently we do not recommend the introduction of the larger description of Gatling for land service. Except against an enemy in the open, the fire of a mitrailleur is comparatively worthless; whereas artillery fire will search out an enemy from almost any position, whether covered by trees, brushwood, earthworks, or houses, and at distances far beyond the range of a mitrailleur."

Notwithstanding the many advantages claimed by Mr. Gatling and others† for the use of a far-ranging mitrailleur, the reasons to the contrary seem conclusive; and we find that the opinion of foreign officers coincides with those of our own Committee as to the advisability of not adopting such a weapon for service in the field to cope with artillery at long ranges.‡

For use against cavalry and infantry, however, a lighter machine gun, firing S.A. ammunition,§ might be employed, and would in certain cases be very useful. So much had been expected of their new arm by the French, that when their armies were vanquished by the victorious Prussians, the mitrailleurs, like all else concerned on the losing side, did not get the credit due to them. Those which they employed were so heavy as to require six horses, while the few taken into the field by the Bavarians under Von der Tann were very defective in mechanism.

Notwithstanding this, however, and the imperfect knowledge then possessed as to their proper tactical employment, we find that they proved at times of great service.

Captain H. Brackenbury, R.A., mentions several instances:—"At the battle of Rezonville," he says, "we have very plain evidence as to whether the French considered the mitrailleuses to be more effective than guns in certain positions, by this fact—that Marshal Bazaine, who was there on the spot himself (near a ravine close to the Bois de Oignons), had plenty of guns under his hand, but had only two batteries of mitrailleuses. To defend the head of this ravine (and this was after

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* The French mitrailleurs, we must remember, were heavy ones, having six horses and considerable range.

† These may be summed up as—(1) Equal range, with greater accuracy and precision than field pieces. (2) Rapidity and continuity of fire. (3) No recoil; therefore no re-sighting or re-laying necessary. (4) Lightness. (5) Greater power of richochet fire. (6) Economy in money, horses, and men.

‡ *Vide* American report of this year.

§ It is not absolutely necessary, of course, that the ammunition used should be the same as that used by the infantry, but still it is very desirable. Neither with our own nor the French machine gun can service S.A. ammunition be used, at present.

having seen previous battles) he brought up his mitrailleuses. Any one who has seen that battle-field, who has seen the way in which the graves are at this point piled almost one upon another, will see how awful the slaughter must have been; and it was due, practically, entirely to these mitrailleuses."

"There is," he also says, "another peculiar case, and that is on the western side of the battle-field of Sedan. On the heights, close to Floeing, there was placed a battery of mitrailleuses. There is, opposite to that, a round hill with wood on the top; and out of this wood and from behind this hill came the Prussian columns. As they came out they were swept down by these mitrailleuses, and they did not succeed. They could not make any progress, but were obliged to go back again, and go round on the reverse slope of the hill, checked by the mitrailleuse."

Another example is given by him of the remarkable work sometimes done by the mitrailleuses, in the defence of a railway bridge at Bazeilles:—"The Bavarian columns came down and endeavoured to cross that railway bridge, preceded, of course, by their skirmishers. Two mitrailleuses only, I believe, were placed behind a garden wall, and they simply swept the bridge, so that the Bavarians could not pass it."

Mr. Winn thus describes the effects of mitrailleur fire at Gravelotte, upon a body of German cavalry:—"It was about 3 o'clock that Malmaison was taken by our (the German) troops, and it was on some Uhlans who tried to cut off the retreat of some Voltigeurs that the mitrailleur so terribly vindicated its character for destruction. A squadron rode forward with its usual pride and confidence; we heard the growl of this truly infernal machine; we saw an unwonted confusion in the Lancers' ranks; they wheeled and retired, leaving behind them 32 horses and as many men. They had unwittingly crossed the fatal line of fire, and had they remained to rescue their comrades, three minutes would have sufficed to put them in the same helpless condition. We had gone forward to the extreme point of the glen, and with our glasses could plainly see the gunners as they placed the fatal plate in the hydra-mouthed cannon."

Colonel Fielding again instances the effects produced at the second battle of Beaugency on a Prussian column of infantry, where clear gaps were cut through one of its angles. The same effect, he thinks, could not have been produced by infantry, as the time necessarily spent in deployment would have given warning to the approaching column. He considers "the proper use of mitrailleurs to be as representing a certain number of infantry, for which there is not room on the ground, suddenly placed forward at the proper moment, at a decisive point, to bring a crushing fire on the enemy."

Captain Knollys, R.A., writing of the battle of Sedan, narrates the effect produced by six mitrailleurs, which were entrenched, and played with deadly effect on the Prussians, who attempted to cross a valley intervening between them and some rising ground about 900 yds. distant. "The numerous Prussian graves on the slope of the Mamelon attest the severe loss they suffered," he says, and afterwards adds—

"In this solitary instance* the effects of the mitrailleurs were confessedly superior to any which could have been inflicted by common shell."

To go through all the evidence taken by Colonel Wray's Committee of 1870-1 of officers who actually saw mitrailleurs used in the field would encroach too much on our space. It is thus summed up by Colonel Fletcher (one of the Committee):—

1. The French officers, and those who witnessed the campaign from the French side, were generally in favour of the employment of mitrailleurs in the field.

2. The Prussian staff disapproved of their introduction into the service.†

3. English officers who were present with the German army, with one exception, considered that for certain purposes they might prove useful adjuncts to field artillery.

Colonel Wray's Committee carried on exhaustive trials between the 9-pr. R.M.L. gun, firing shrapnel, a small (0·45-in. bore) Gatling gun, and six Guardsmen, armed with the Martini-Henry. In a series of eleven trials, where the firing took place at ranges from 300 to 1200 yds., and under various conditions as to time and distance, the Gatling made 2699 hits, the 9-pr. gun 1620, and the Martini-Henry 718.‡ (*Vide* Appendix for tables of practice).

This, of course, merely proved that under certain circumstances the fire of a mitrailleur would be very deadly beyond the range of case shot; but it must also be borne in mind that with known short ranges this fire is certain, while shell fire is always more or less uncertain.

With these facts and this evidence before them, the Committee, in their final report, laid down distinctly "that the mitrailleurs should be treated purely as defensive weapons, and that they should in general be entrenched, and kept as far as possible masked from artillery fire; that the so-called small Gatling of 0·45-in. calibre—of which the destructive effect against troops in the open, at ranges up to 1400 yds., is estimated as being nearly three times that of the 9-pr. field gun—should be lightened, so as to be easily drawn, with its carriage and ammunition, by two horses, and on an emergency by one." Also "that the field artillery should not be reduced by a single man or horse for the sake of substituting mitrailleurs."

To assist in defending such positions as villages, field entrenchments, &c., the Committee considered that the small Gatling would be found invaluable.

In these opinions we find by their report that the Swedo-Norwegian Commission agree. They say:—"The Committee believe that this arm is chiefly of a defensive nature, which nevertheless does not diminish its

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* This officer was on the German side of the theatre of operations.

† We must remember that the Prussians had no opportunity for testing their merits for defensive purposes, wherein their value seems principally to lie.

‡ This was on level and fairly hard ground.

importance or merit, even in field warfare;" adding afterwards that they "cannot too strongly insist on the importance of not confounding mitrailleurs with artillery, as much on account of their effect, as the proper nature of their employment."

Our first conclusion (p. 425), seems to be borne out, in so far as mitrailleurs have been shown to be terrible weapons under certain circumstances. It has been shown also that it would be most unadvisable to replace even a single field gun by such a machine. But then comes the question, whether by taking into the field a certain proportion of this fire-arm we gain "an advantage commensurate with the additional expense and trouble, and the addition to the *impedimenta* of an army."

This question cannot well be answered without considering the proper tactical use of mitrailleurs, and the organisation necessary for field service.

Tactical Use of Mitrailleurs.

In answer to questions on the subject, General Walker, who was with the Prussians throughout the war, says:—"Where is the tactical place of the mitrailleur? I believe the mitrailleur likely to prove effective as a gun of position in street fighting, in the defence of villages, of defiles, and in the flanks of permanent works; but I could not consent to spare one single field gun from the proportion of artillery adopted in this country as proper for field operations for the purpose of replacing it by a mitrailleur. I think that the mitrailleur might prove very effective if employed against a half-disciplined enemy, inadequately supplied with field artillery; but its effectiveness presupposes that the opponent is obliged to advance on the narrow front which is covered by its range."

Colonel Hamley, critically considering the subject, writes:—

"The question of employing the mitrailleuse may, in a great measure, be argued without further reference to the experience of war, because all the circumstances on which efficiency depends have been ascertained by experiment and by the testimony of observers, except one—namely, the frequency with which opportunities for its effective action may be expected to occur; and even that may be fairly estimated without actual experience.

"In the case of an army about to attack, it is more than ever desirable to precede the advance of troops by a concentrated fire of artillery. If Gatling mitrailleuses were used for this purpose, they must move forward to within 1200 yds. of the enemy's line. As they could not always—perhaps not often—choose sheltered ground for their position, they would, while taking it up, and afterwards, be exposed to the enemy's artillery at easy range. Even if protected from this, their own fire would generally be directed on troops secured from it, either by obstacles already existing, or by those constructed for the purpose. For this end, therefore, they may be pronounced absolutely useless, and must be left out of the account in considering *offensive* operations.

"It is perhaps partly on this ground that the Prussians, whose tactics have been invariably offensive, have rejected them.

"For defensive purposes, in order to compare them with field guns, the effect on the enemy must be estimated, not over the limited range within which the Gatling is effective, but over the whole extent of ground on which the enemy would be exposed to projectiles when advancing. This would, on open ground, be three times the range of the Gatling; and the total loss caused by a field gun throughout the advance would probably far exceed that inflicted by the mitrailleuse within its own more limited range.

"But, on the other hand, many cases must arise in war in which the long range of the field gun would be superfluous, while the mitrailleuse could be employed under its own conditions of effectiveness. In all countries not absolutely flat, troops may often engage with no greater distance than 1200 yds. between the hostile forces. Thus the French troops attacking Hougomont would have been always under the effective fire of Gatlings from the British position.

"In broken or mountainous ground, there will always be parts of the field where the assailant's troops will be sheltered from fire up to short range, and would only begin to suffer loss on issuing from their shelter. Thus, in all the *northern* part of the field of Solferino, the defenders (had they prepared the position) might have effectually used mitrailleurs, but not so in the plain forming the southern part of the field.

"It may therefore be fairly inferred that it would be quite inexpedient to diminish the field artillery of an English army, in a foreign war, by supplying it with weapons which, if present at all with marching and manœuvring troops, must to that extent occupy the place of guns. But there are cases in which *protected* Gatlings would bring the most effective possible fire to bear on an advancing enemy, especially if approaching on a narrow front—as when issuing from a village, or moving in a hollow road, or crossing a bridge, and in which guns would be much better employed elsewhere. Therefore, for *home* defence, or when holding selected positions, there would often be opportunities for employing them in preference to long-ranging artillery. For such circumstances, therefore—namely, the defence of this country, or when it may be foreseen that our troops will be engaged on the defensive—as to cover an embarkation—a certain supply of Gatlings, say one to twelve guns, would be of great value if kept in the depôts, and only moved into position when the time for using them had come."

We have here an admirable summary of the tactical uses of mitrailleurs, as might be expected from the writer.

It is clear that machine guns would only be used for defence; as Captain H. Brackenbury well puts the question:—"What do we see in all those battle-fields but one single plan of attack? First the infantry is utterly demoralised by the crushing fire of a mass of artillery concentrated on it; then masses of skirmishers or columns are sent up to attack. What can you do with the mitrailleuses? They are of no value in the attack; but in defence, in certain positions, I

believe them to be invaluable, and I hope to see them introduced into our army, but not hampering the infantry by being rigidly attached to them."

For bush and mountain warfare the mitrailleur* does not seem well adapted, except perhaps for defence of field works or stockades, if the ground be sufficiently clear.† Some Gatling guns of 0·45-in. bore were sent out to the coast of Africa for service in the Ashantee War; but, so far as we have heard, these have not proved so useful‡ as the small guns,§ which have also been employed there.

However portable such arms may be made, they would be useless against the weakest defences, as well as in broken rocky ground, where the moral effect produced, even by a small shell, is great, particularly when nations more or less uncivilised are in question.

It may be remarked that mitrailleurs require flank support by infantry, when in action, even more than artillery does. Both at Paris and Le Mans the Prussian skirmishers captured mitrailleurs by avoiding their direct fire, advancing on their flank and then closing in.

Conceding that mitrailleurs should be brought into the field for defensive purposes, we have to settle whether they should be attached to infantry or cavalry, or form part of the artillery of an army. Our own Committee and the military opinion of most other nations are in favour of making them a supplementary part of the artillery force, as has been the case, so far, when they have been used in actual war.

To attach machine guns to infantry would hamper the movements of the latter, who would also, as a rule, select ground for advance not suitable to wheeled carriages. The Hungarian Government, indeed, proposes to attach mitrailleurs to regiments of militia, to give moral and material support; but such a scheme seems radically wrong. The duties required of the *personnel* of mitrailleur batteries are quite distinct from those of infantry, and both officers and men should be highly trained in the tactical use of their particular arm.

It has been suggested that mitrailleurs should be attached to each cavalry regiment for use with piquets, and in covering an advance or retreat. Cavalry, it is said, act principally in an open country, where mitrailleurs would be specially effective. But, on the other hand, in

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* A small Gatling, to fire from a tripod, was proposed for mountain warfare, but it turned out a failure when tried.

† We find, indeed, that 50 Gatling guns of 0·45-in. bore have been made in the United States for service with troops on the frontier. The Director of Ordnance, in his Report of 1873 (to Secretary of State for War) says, regarding them:—"These guns are of such dimensions and weights as to be easily transported on pack animals. Their efficiency can only be tested by use; but it is thought they will be far more effective in Indian warfare than the mountain howitzer heretofore in use." Whether this opinion is correct or not must depend on the nature of the country operated in. On the flat western prairies they might be very effective.

‡ Major Rait, C.B., has informed me, since the above was written, that these mitrailleurs were found cumbersome, and so top-heavy on the rough road traversed, that the fittings, sights, &c., had to be removed for travelling. They were not taken further than the Prah. These Gatlings were mounted on special carriages.

§ 7-pr. steel R.M.L. (Some 4⅖-in. bronze howitzers, S.B., weighing 280 lbs., were found to be too heavy for carriage).

country sufficiently open for cavalry operations, the probability is that horse artillery, with superior range, would soon silence the mitrailleurs.*

The duties of cavalry soldiers are sufficiently arduous as it is, and to add to them others quite foreign to their own would not be at all advisable.

Organisation for Field Service.

We find that the French used batteries composed of six mitrailleurs, while the two Bavarian batteries employed were composed of four each. These mitrailleurs, however, required six horses for draught, and also more *personnel* than would be used with our Gatling, for instance.

For organisation in Russia and Spain, *vide* Note, p. 436.

Colonel Wray's Committee proposed that twelve Gatling guns should constitute a battery, in accordance with the detail given in the Appendix.

It will be seen that on the line of march the space occupied by such a battery, as compared with that taken up by a 9-pr. R.M.L. gun, would be 156 instead of 353 yds.

The number and ranks of the officers would be similar to those in a field battery; but there seems no necessity for this. Four mitrailleurs may be looked upon as the largest number likely to be employed in any particular case. The organisation proposed by the Committee is stated, indeed, to be meant "for organisation, and not for tactical purposes." Would it not be better to have four mitrailleurs, in the charge of one Captain and one Subaltern officer, as the tactical unit? Two of these, if necessary, might be united for larger administrative purposes under a Major, or four under a Lieut.-Colonel; but it seems to me that the tactical unit should, as in the case of field artillery, be also thoroughly recognised in organisation.

The Swedo-Norwegian Committee say:—"We consider that a mitrailleuse battery should consist of four pieces. Doubtless two mitrailleuses (half a battery) could alone strongly reinforce a position; but it would be preferable, in a case of importance, that a whole battery should be detailed, in order that the tenure of a position might not be imperilled by the dismounting of one or two mitrailleuses. On the other hand, circumstances are not likely to arise when the employment of more than four mitrailleuses would be necessary."

As the mitrailleur can only be used advantageously for defensive tactics—and that on exceptional occasions, when the ground in front is clear of cover—all will agree, I think, that the reserve of a division is the proper place for batteries of this arm, if it be taken into the field.†

* Count Thürheim claims to have driven back a battery of French artillery with his revolver cannon, or mitrailleurs, at Culmiers, but the practice of the battery was apparently very bad.

† The Special Committee of 1870–1 recommend "that they should be kept with the reserves, for the express purpose of increasing infantry fire at critical moments, in the same way that guns of position are used for strengthening the fire of field artillery."

The Swedo-Norwegian Committee say:—"It follows, from the duties assigned to the mitrailleurs, that they should be under the command of the divisional chiefs; that they should form part of the divisional reserve, and not be attached to brigades or battalions except the latter are exceptionally employed under circumstances when mitrailleurs might appear necessary."

The proportion of field artillery (including reserves)—at most 3 guns per 1000 men—is certainly calculated as being the maximum which can accompany an army without hampering and embarrassing the latter by excess of *impedimenta;* but we have seen that it is proposed to use only two horses for the carriage of a Gatling, so that the space occupied on the line of march would be very small, and it appears that we might add with advantage a small number, say twelve (or even more) Gatling guns to the proportion of artillery—seventy-two guns*—laid down for an Army Corps of 30,000 men, to be attached to reserve of same, or distributed amongst divisional reserves.

It must be remembered, however, that great care and caution have to be exercised in the introduction into our field equipment of an arm of such limited use.

If we do employ any, they should be the very best obtainable; so that the wisest policy is not to manufacture many till greater mobility than our service Gatlings possess, as well as the other essentials mentioned at p. 429, have been attained.

As soon as this is the case, the necessary number for the reserve of our army can, with the manufacturing capabilities of this country, be produced at very short notice.

II.—Employment of Machine Guns for Fortresses or Siege Works.

There is very little difference of opinion as to this mode of employing machine guns. Where space is limited, the front clear, and range known—as in permanent works—these weapons would be most useful in caponnières, counterscarp galleries, &c., for the defence of ditches, as well as of the short flanks of works,† while in a breach their effects would be most formidable.

	R.H.A. Guns.	Field Battery.	Total.
*Reserve	6	18	24
3 Infantry divisions (each 12)	—	36	36
1 Brigade cavalry	12	—	12
	18	54	72

† The Swedo-Norwegian Committee say:—"In warfare of position, or fortresses, these arms have so great and so evident an importance that opinions cannot differ thereon." The Americans carried on exhaustive trials last year between Gatling guns, field guns, and 8-in. siege howitzers; and the report of the Board of officers concerned was strongly in favour of using some of these weapons for flanks of works. In consequence, the Secretary of State for War has recommended to Congress the appropriation of 292,600 dols. for the immediate purchase of 209 Gatling guns and carriages, to be in position by the 1st July, 1874. Another Special Board, U.S. army, reporting as to advantages of mitrailleurs in defending short flanks, say:—"There can be no question that the great volume of fire of the 8-in. howitzer (1173 balls discharged in one minute, or double that number if necessary), would prove irresistible on the short lines of our permanent fortifications. Besides, these guns admit of the use of shells when needed." In cases, however, of a simultaneous attack on the curtain and faces of adjacent bastions, they go on to say, "it

Colonel Wray's Committee recommend the introduction of the heavy Gatling gun of 0·65-in. bore for coast defences; considering that it would prove useful against boat attacks, or for keeping down the fire of ships engaging forts at close quarters or attempting to force a passage, by pouring an incessant fire into their ports.

The best construction of this weapon not having been determined, none have been added, as yet, to the armament of our forts.

From their comparative lightness, and the absence of recoil, they would prove very serviceable weapons in advanced trenches, and doubtless will form an adjunct to siege trains of the future, for repelling sorties, &c.

(Tables of American trial practice—note † p. 433—between 8-in. howitzer and Gatlings, are given in Appendix).

III.—Employment of Machine Guns for Naval Purposes.

Here, again, opinion seems unanimous as to the advantages of using mitrailleurs for ships' tops, to repulse boarders, and for boat service in certain cases.

They have not actually been used in naval warfare, so we have nothing but experimental data to go upon.

For covering a landing they would no doubt be useful, should the beach and adjoining country be open—as would usually be the case; though even then they should supplement, and not supersede, the heavier natures of guns used for boat or field marine service. Notwithstanding that great advantage, in a boat, of absence of recoil, their manifold disadvantages must not be lost sight of.

I have seen them strongly recommended for boat expeditions up rivers; but surely in such cases as where the gallant Commodore Commerell was wounded the other day,* the smallest gun which could throw a shell into the bush would be better, for what effect can a mitrailleur have against dense jungle?

In our service, twelve of the 0·65-in. bore and a similar number of the 0·45-in. calibre have been ordered for trial by the navy, until the question of the best construction be definitely settled.

We may now pass from the more general question to details, and consider what mitrailleur constructed up to this time it would be most advisable to adopt for field service.†

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would be impossible to serve the opposite howitzers with the freedom a good defence would require," on account of the risk to gunners in opposite casemate. The Board therefore recommended one Gatling gun "for each flank of casemated forts, even to the displacement of the howitzer when there is but one flank embrasure, if the scarp can be readily approached, and if there be a line of embrasures raised but a few feet above the ground." (For trial practice, *vide* Appendix).

* When reconnoitring the river Volta, on the coast of Africa.

† Having found a mitrailleur which would satisfy these conditions, it would be easy to modify it for fortress or naval service, where so great mobility is not necessary.

The following seem to be the principal *desiderata*, viz. :—

1. Rapidity of fire (which should reach the rate of 300 or 400 rounds per minute).*

2. The mechanism should not be easily put out of order, even if the rapidity of fire exceed occasionally the normal standard.*

3. The mitrailleur, with a considerable number of rounds (say 4000) should be capable of draught by two horses.*

4. The piece should be readily separated, if necessary, from its carriage; and be capable of conveyance by hand, should the place be inaccessible to horses.* No special tools should be required for this, save a powerful screwdriver or hammer.

5. It should be furnished with automatic apparatus for giving and regulating horizontal spread of bullets, at various angles, and be capable of easy elevation, throughout a sufficient height.*

6. The ammunition used should, if possible, be interchangeable with that of infantry.

7. Two men should be capable of performing all the duties of the piece when under fire.

N.B.—It should be particularly noted that with this weapon some sort of range-finder should be employed, as most strongly recommended by the Committee of 1870–1, who proposed the adoption of that invented by Captain Nolan, R.A. Though it seems advisable that every field gun should be furnished with range-finders, it is possible to find out by trial shots, from a gun, an approximation to the correct range, but not so with mitrailleurs.

The following table partially shows how far the service machine guns of different nations fulfil the above requirements :—

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* These are laid down by the Swedo-Norwegian Committee.

Nation.	Nature of mitrailleuse.	1 Nominal rapidity of fire. Rounds per minute.	2 If mechanism is capable of greater rapidity.	3 Weight. Gun complete.	Carriage complete.	Limber, empty.	4000 rounds (about).	Total.	4 No. of men to carry when dismounted.	5 If capable of lateral spread.	6 Ammunition used.	7 No. of men for service in action.	Range up to	Remarks.
				cwt. qr. lb.	cwt. qr. lb.	cwt. qr. lb.	cwt. qr. lb.	cwt. qr. lb.					yds.	
England	Gatling, 0·65-in. bore.	—	—	7 2 14	7 2 13	—	—	—	?	Yes.	Special.	?	—	For naval and coast service.
〃	〃 0·45-in. 〃	300 to 400	No.	3 3 24	5 2 10	7 0 3	4 0 0	20 2 9	?	Yes.	Special.	2	2400	Up to 1200 yds. produces maximum effect.
Russia	〃 ? 〃	—	No.	1 0 0	12 1 10	9 2 10	?	?	?	Yes.	—	—	—	360 or over in their service for fortresses.
〃	Nobel.	About 300	No.	1 0 0	2 1 8	5 1 4	3 0 8	11 2 20	?	Yes.	Special.	?	1870	For service in the field.
France	The French.	100 to 150	No.	?	?	?	?	?	?	?	Special.	?	?	〃
Austria	Montigny and Christophe.	200	No.	3 2 5	9 3 4	9 1 20	?	?	?	?	Werndl S.A.A.	?	1000	〃
Prussia	The French.	As above	No.	—	—	—	—	—	—	—	—	—	—	〃
Turkey	Gatling.	〃	No.	—	—	—	—	—	—	—	—	—	—	?
America	〃 0·45-in. bore.	—	No.	?	?	?	?	?	?	?	Berdan.	—	—	For flank defence, and frontier war.
Sweden and Norway	Palmcrantz.	400 to 500	No.	2 2 6	2 2 2	?	3 0 0	?	2	?	Special as yet.	1	1400	Only proposed, not adopted.

NOTE.—Spain also employs mitrailleurs with her field artillery, each brigade of which contains one mitrailleur battery of six pieces. For field service, Russia has forty-seven Gatling batteries of eight pieces; one battery forming a part of each brigade of field artillery.

PART II.

DETAILS OF CONSTRUCTION OF CERTAIN MITRAILLEURS.

With reference to Note *, p. 423, I feel it necessary to make some apologies for the meagre and insufficient information given in the foregoing table, and also to explain why full details as to the construction of some mitrailleurs are given below, but few or none as to that of others.

Regarding the table, I have not found it possible, as yet, to fill it in with absolute certainty that the weights, &c., would be correct, and have therefore thought it better to leave it as it is, in hopes of being able to furnish a more complete table at some future time.

Full details of the construction of our service Gatling are given, for reasons sufficiently obvious.

The French mitrailleur, and that of Christophe and Montigny, have been often described elsewhere; and, moreover, their type seems one not likely to be copied again.

The mechanism of the Palmcrantz mitrailleur has been minutely detailed, not only because of the many advantages the weapon itself plainly possesses, but also on account of the novelty of the mechanism, which, though complicated, from the number of parts, is otherwise of much merit.

At present, however, our own Gatling, of a simpler construction though slower in fire, seems a better weapon.

The Gatling Gun.

This belongs to the description of mitrailleurs where the barrels revolve, and are charged simultaneously. Each barrel has its special lock, which accompanies it during revolution, and is also capable of motion backwards and forwards. It pushes the cartridge into its barrel, then serves as a breech, and afterwards extracts the empty cartridge. Each lock has a striker with spiral spring, and an extractor.

The system is caused to revolve by means of a crank fixed on the right side of the piece.

The following improvements have been made in those of more recent construction:—*

* Our service Gatlings possess all these improvements, but the Swedo-Norwegian Committee think that if the normal rate of fire is exceeded they are likely to get out of order; and also that the mechanism is too complicated.

Magazines containing 20 to 25 cartridges each, have been replaced by drums containing, with our service arm, 240 rounds.

The spring extractor has been improved, so as to ensure the empty case being withdrawn.

Each lock can be taken out separately, and replaced by a new one.

An automatic "scattering" arrangement has been added, which can be put in gear or not, as required, and which is worked by the crank which moves the system.

300 to 400 rounds per minute can be fired from this mitrailleur.

Two men are sufficient to serve one in action.

We have two natures in our service—the 0·65-in. and the 0·45-in. bore.

Construction in detail. (*Vide Plate I.*)

Ten steel barrels, rifled on the Henry principle, are fixed in a circle round a centre shaft of steel. To this shaft are keyed two gun-metal discs, through one of which the muzzle ends of barrels pass, while their breech ends are screwed into the other.

The shaft itself is fixed in a "gun-frame" (*aa*, Fig. 1) of wrought-iron, made of two bars connected in front of muzzles by a curved cross-piece (*n*, Fig. 1). The rear ends of this gun-frame are connected by screws to a cast-iron box, or "breech-casing" (*C*, Fig. 1), which contains the mechanism. In this casing is a vertical diaphragm, through which the shaft passes towards the breech, and the breech end of the casing is closed by a "cascable-plate" (*D*, Fig. 1) of cast-iron.

Inside the casing, upon the rear end of the shaft, is a small (pinion) worm-wheel (*W*, Fig. 2), which gears into a worm (*f*, Fig. 2) on a crank-shaft or spindle (*gg*, Fig. 2), which passes into the breech-casing on the right side, and at right angles to the main shaft. By turning a crank-handle secured to this spindle, the main shaft and barrels are caused to revolve. When not in use, this handle is pushed in out of the way.

Fastened by screws to the gun-frame, is a "pivot-block" of gun-metal (*p*, Figs. 1 and 3); a pivot (*P*, Fig. 3) passes through this, and into an iron trunnion-plate (*ee*, Figs. 2 and 3), and upon it the system turns when lateral spread of bullets is required.

The trunnion-plate has projections, or trunnions, on which the system revolves for elevation, and is secured at the rear end by a bolt and nut to a locking-bolt plate which fits into an undercut slot in bottom of breech-casing.

When a scattering fire is required, the frame, barrels, &c., turn on this "block" through the required arc by means of an automatic arrangement (*AF*, Fig. 2) worked by the crank-handle before mentioned. When such is not required, the fire is concentrated by putting this arrangement out of gear, and preventing any transverse movement by means of a "locking-bolt" (*l*, Fig. 2) let down into a slot in trunnion-plate at the rear.

SECTION THROUGH TRUNNION-PLATE, TRUNNIONS AND PIVOT BLOCK.

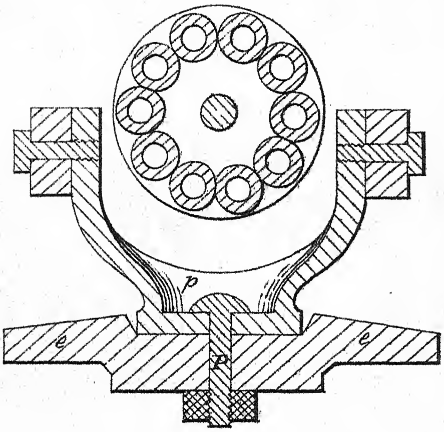
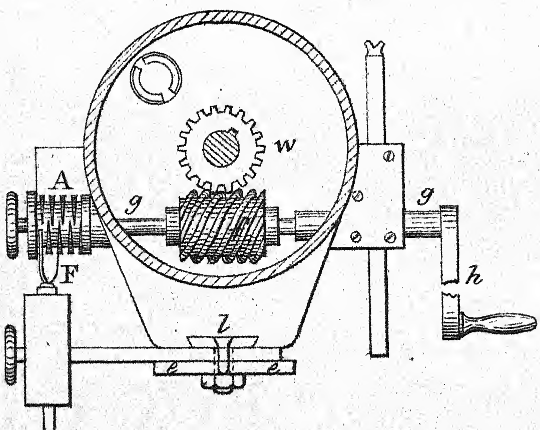


FIG 2.

ELEVATION OF BREECH END WITH CASCABLE PLATE REMOVED.



SERVICE GATLING GUN 0·45 BORE.

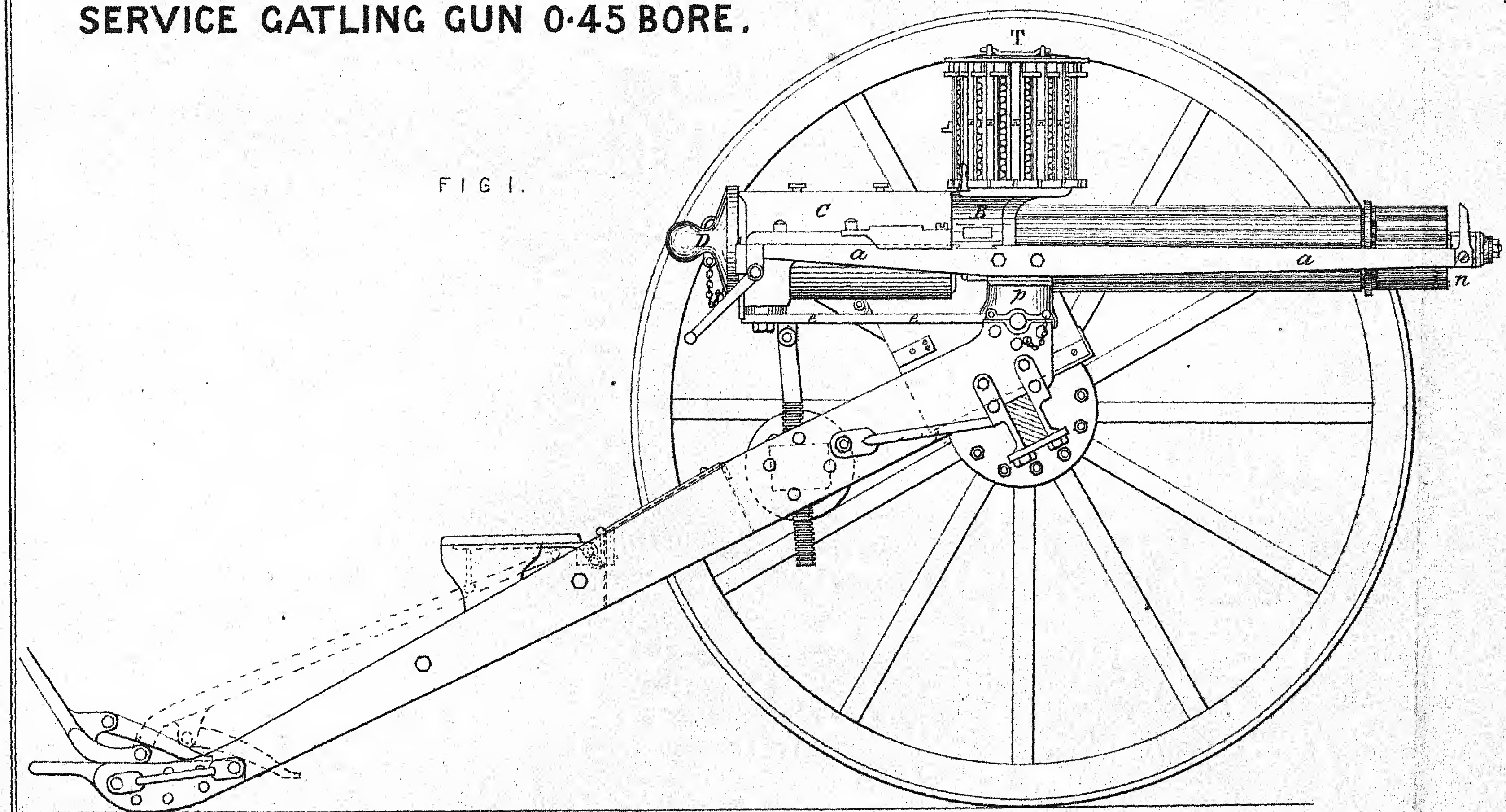


FIG I.

FIG 3.
SECTION THROUGH TRUNNION-PLATE, TRUNNIONS AND PIVOT BLOCK.

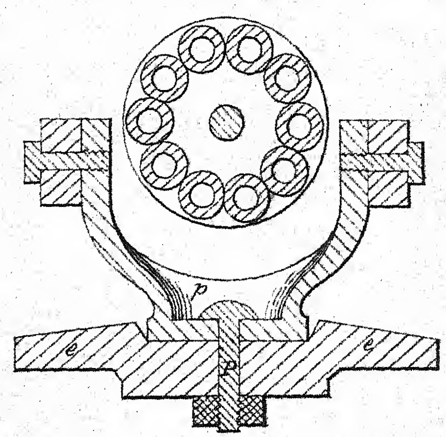


FIG 2.
ELEVATION OF BREECH END WITH CASCABLE PLATE REMOVED.

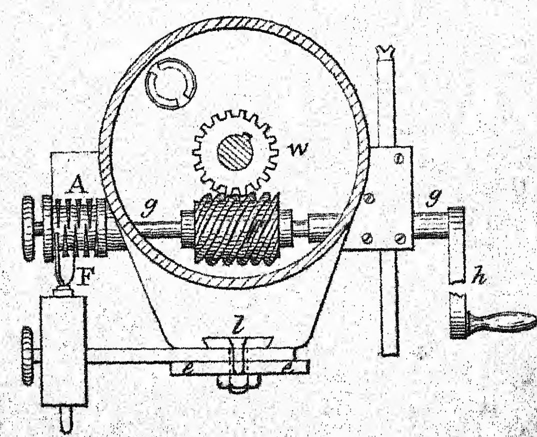


FIG 5.
PLAN–BOTTOM OF DRUM

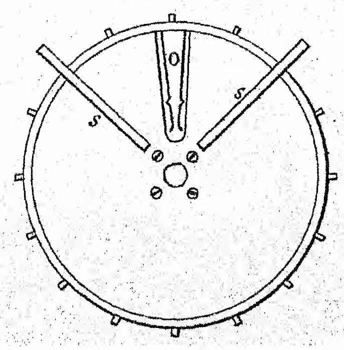


FIG 6.
HORIZONTAL SECTION THROUGH DRUM.

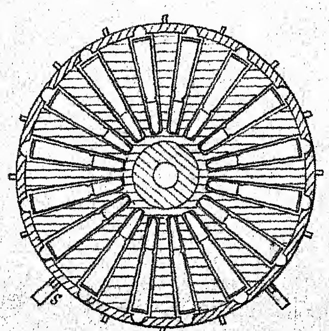
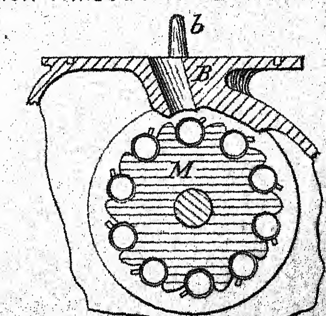


FIG 4.
SECTION THROUGH HOPPER & CARTRIDGE CARRIER.



On the main shaft in rear of the barrels a cast-iron cylinder, or "cartridge-carrier" (*M*, Fig. 4) is fixed. This has ten longitudinal grooves, corresponding with the ten barrels. A gun-metal cover, or "hopper" (*B*, Figs. 1 and 4), hinged at one side, drops over it. The cover has a longitudinal slot, corresponding to the opening in the "feed drum"* (*T*, Fig. 1), which rests upon the upper surface of "hopper." As each column is exhausted, the drum is turned round by hand until the next one corresponds with opening in hopper.† Through this slot the cartridges drop (as the shaft revolves) into the several grooves, ready to be pushed by the lock-plungers into the barrels corresponding.

In rear of this, and inside the breech-casing, is placed the "lock-chamber," which is keyed to, and revolves with, the main shaft. It is a cylinder of cast-iron, having longitudinal channels through which the "locks" pass.

Upon the main shaft, again, and against the back of the "lock-chamber," is secured a cast-iron "rear guide nut," which keeps the parts firmly together. The locks rest partly upon the outer circumference of this nut; and in the grooves on which they fit, as well as in the channels in lock-chamber, are small slots, in which run studs on the locks, in order to prevent the latter revolving save with the shaft.

Inside the "casing" is a curved gun-metal plate, or cam, by means of which, as the shaft and lock-chamber revolve, the locks themselves are pushed forward or back. A piece of steel is let into the front of this cam, against which the butt of each lock bears at the moment the barrel is fired.

There is also a steel cam, called a cocking-ring, which, as the lock-chamber revolves, draws back and then releases a spiral spring acting on the "firing-pin" or needle of each lock.

The Lock.

The lock consists of a steel tube, or "plunger," about $11\frac{1}{4}$ ins. long, the front end of which, for about 4 ins., is smaller in diameter, and has only a pin-hole running through it.

The remainder is hollow, and slotted out on one side. Its breech end is closed by a steel plug, or "butt," screwed in.

Inside is a steel bolt, or "hammer," having a projection at the side which passes through the slot in the tube, while to the front part of it is attached a firing-pin, or "striker," of steel.

A spiral spring is placed over the hammer, being retained by the "butt."

To the outside of the tube or lock is fixed a steel extractor, having

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* This drum is of metal, fits on a pin (*b*, Fig. 4) in centre of hopper, and contains 240 cartridges, in 16 perpendicular columns or channels. It weighs, when full, 50 lbs.

† In the smaller Russian Gatling, used with their batteries of this arm for field service, the drum is turned by an automatic arrangement—an improvement much required in our service Gatling.

a hook which seizes the rim of cartridge and draws it out as the lock is being withdrawn.

Action.

When the gun is in action, five cartridges are always in process of loading, and five are in different stages of extraction. Thus, as the system revolves, cartridges drop from feed-drum through slot in hopper, successively, on the ten grooves in cartridge-carrier; as each lock comes in contact with the cocking-ring, the hammer is drawn back and spring compressed; further rotation brings the lock against the gun-metal cam, which pushes it forward, driving before it a cartridge from the carrier into its particular barrel. The breech is thus closed, and as the butt comes opposite the steel plate in cam, the cocking-ring releases the spring, and the needle fires the cartridge. The system continues to revolve, and the lock now being drawn back within the chamber, extracts the empty cartridge-case while retreating, and the latter falls to the ground.

The 0·45-in. gun is sighted with a tangent and fore-sight up to 2400 yds. (8° 23′ elevation).

	cwt.	qrs.	lbs.
Weight of gun	3	3	24
" carriage and limber (empty)	12	2	13

Ammunition in axletree and limber-boxes, 2400 rounds per gun. Weight, about 2 cwt.

Also to be carried in two ammunition carts for six guns, 21,760 rounds, or about 3600 rounds per gun.

The ammunition used is not the Martini-Henry; for though it would be advisable to employ it, the difficulties in the way have not yet been overcome.

The bullet of lead and tin weighs 480 grs., and the powder charge is 85 grs. The cartridge-case is of brass, drawn solid.

The Mitrailleuse of Nobel.

This mitrailleuse is identical, in all its principal parts, with the Gatling gun.* It seems to have rather lost than gained in efficiency by the greater number of the so-called improvements, according to the Swedo-Norwegian report.†

These specially aimed at a reduction of weight, and an increased rapidity of fire.

The reduction of weight was obtained by the construction of a lighter carriage, detrimental to the accuracy of fire, and by a diminu-

* It has a gun-metal cylinder, corresponding to frame and outside of the Gatling. The main shaft is hollow, and of steel, and is turned by an organ handle at rear end. It has two bearings—viz., the cascable plate in rear, and the front part of external tube.

† The Russian authorities, however, seem satisfied with their weapon; and we find that when the new organisation is complete (as it probably will be this year), they will have mitrailleur batteries of eight guns each—*i.e.*, one battery to each brigade of field artillery.

tion in height of the breast of the piece; also by reducing the number of barrels to six, and decreasing their length.

Increased rapidity of fire seems to have been aimed at by the fixing of the crank or handle upon the axis of motion of the system, so as to act directly. This rendered the rotation more rapid; but the drums had to be replaced by small magazines, containing 25 cartridges each, the result of which is that continual changes of magazine have actually reduced the rapidity of fire which it was sought to increase.

This mitrailleuse has also undergone several alterations tending to the better insertion of the cartridges, and the better extraction of the empty cases.*

The French Mitrailleuse.

The French mitrailleuse is composed of 25 barrels, fixed in five layers, one above the other; the whole surrounded with a bronze casing, so as to give it the appearance of a field gun.

This casing is prolonged to the rear, when it forms a box open at the top, in which the loading apparatus is moved backwards and forwards by means of a screw placed in prolongation of the medial line.

The loading apparatus is composed of two parts—viz., 1st, a cartridge-plate, with 25 holes corresponding to the barrels, and in which the cartridges are placed; and 2nd, a firing arrangement which contains 25 locks, each composed of a piston and a spiral spring.

In loading, the cartridge-plate and the firing arrangement are carried forward by the screw, during which operation the cartridges are partly pushed into the barrels; the pistons being brought up by a closing disc, which also produces the cocking of the piece.

This closing disc has 25 holes, and can, by means of a lever-handle fixed to the right side of the piece, be drawn sufficiently to the side to allow the pistons to pass through the corresponding holes, and so to ignite the cartridges. The number of rounds which can be habitually fired with this mitrailleuse is only 100 to 150 per minute.

Its service is laborious, and it easily gets out of order. It is also possible for the cartridges to be fired before the breech arrangement is properly closed—a very serious defect.

The Mitrailleuse of Montigny and Christophe.

This mitrailleuse resembles the French in general principles, but differs from it in the following details:—

It is furnished with 37 barrels instead of 25, and the screw by means of which the loading apparatus is brought into play is replaced by a lever moving in the same vertical plane as the medial line.

The handle which gives rotation to the closing disc of the "pistons

* This description is taken principally from the Swedish report, but it is believed that a drum similar to that used with our Gatling is now employed with the Nobel gun, as mentioned already.

and strikers" is also replaced by a long lever, which moves on the right side of the piece, parallel to the preceding one.

This mitrailleuse has fired as many as 350 to 400 rounds per minute. Under ordinary circumstances, however, this rate cannot be expected. We may take its normal rate of fire as about 200 rounds per minute.*

The construction appears simple, but it is really somewhat complicated, the mechanism being composed of a number of parts. Notwithstanding these defects, it is solid, and not easily liable to get out of order.†

The Mitrailleuses of Winborg and Palmcrantz.

(As described by the Swedo-Norwegian Committee's Report).

The inventors above named submitted for trial two mitrailleuses, on the construction of which the Committee do not give a detailed report, as the inventions have not yet been patented.

The earlier in date of these pieces—called No. 1—has ten working barrels, successively charged from a magazine containing 100 cartridges.

The construction is very simple and solid, comparing well in these two particulars with the Gatling gun.

In the experiments carried out by the Committee, the mitrailleuse No. 1 proved itself to be perfectly accurate, but the rapidity of fire rarely exceeded 300 rounds per minute. If this limit was passed, the sticking of a cartridge was apt to lead to delay in the fire.

This mitrailleuse is not liable to damage from rust; its mechanism being entirely protected, and almost altogether of bronze.

It only weighs about 200 lbs., and its magazines would not much increase the weight of the ammunition. It has a lateral pointing apparatus, and a scattering arrangement. The former is of the usual construction; the latter is simpler than other similar known arrangements, and also easily fixed and worked.

Under no circumstances are more than two men required for the service of this arm; and should "scattering" not be deemed requisite, one man will suffice.

Mitrailleuse No. 2 consists of ten barrels, placed in the same horizontal plane. They are charged simultaneously, and one magazine is capable of containing 250 rounds.

The discharge may take place as a salvo, or round after round.

The whole of the mechanism is put in motion by a lever, working horizontally on the right side of the piece.

The construction of this mitrailleuse is far simpler and stronger than that of all others known,‡ and of a nature little liable to derangement by rust or fouling.

* While changing the discs, one is more than usually liable to accidents, which would considerably reduce the rate of firing.

† A full description of this mitrailleur, with plate, is given in a paper of Major Fosbery's, in "Journal, U.S.I.," No. LVI. pp. 546–7. Mr. Goddard's invention of 1853 (p. 421) somewhat resembles this arm.

‡ As will be seen further on, the simplicity claimed is rather doubtful.

During the experiments carried out by the Committee, which occupied about eight days, this mitrailleuse was stored in a damp cellar, and not cleaned between the firings. The rust appeared in no way to interfere with the working of the mechanism. 450 rounds per minute were fired from it—a magazine being emptied with a rapidity amounting to a discharge of 600 rounds per minute. This rapidity did not interfere with the regular working of the mechanism.

The inventors contemplate shortening slightly the motion of the lever, in which case the Committee believed that a rate of fire of from 400 to 500 rounds per minute could be attained with certainty.

It can be served in all cases by one man.

No. 2. (According to Report of French Committee). Vide Plate II.

The report of the Swedo-Norwegian Committee of 1872 gave only a general description of this mitrailleuse, but no account of its mechanism. Since the date of that report, a French Committee has experimented with this weapon at Bourges, and in the "Revue de l'Artillerie" of February, 1874, we find a full description, illustrated by plates. From this account, the following details have been taken.

Before entering into them, it may be well to mention the results of the French experiments, and the conclusion their Committee arrived at, which differ somewhat from those of the Swedo-Norwegian officers.

2850 rounds were fired with effect, as shown by table below. Two rows of targets (44 yds. apart) were used, each row being about 8 ft. high and 86 ft. in length.

Distances. (about).	Number of bullets fired.	Percentage of bullets striking.	
		1st row.	2nd row.
yds. 440	500	33·6	38·5
880	500	52·3	42·7
1100	1350	37·2	31·8
1320	500	19·8	25·8
Total	2850		

Some of the firing was slow, and at other times it was carried out as quickly as possible, at the rate of 500 rounds a minute.

Several accidents happened during this rapid firing, which interrupted it for a certain time. They were principally owing to the cartridges not acting sufficiently as a gas check.

In the most serious, which occurred twice, the striker was driven violently back out of its groove, (by the gas), pushing the cock back with it.

The cock became fixed in the longitudinal slit which guided it, and

54

the motion of the lever was stopped until the striker and cock had been put back in their places.

Other stoppages were caused by difficulty of extraction when the rapidity of fire was great; the empty cartridges not being withdrawn quickly enough.

The Committee concluded—

1. That the closing of the breech was faulty (not sufficiently close); and that, unless a stronger cartridge affording a sufficient gas check was used,* some change in the mechanism was necessary on that account.

2. That the striker should be furnished with a stop, to prevent its being driven backwards out of the piston or plunger; and an arrangement made for the continual supply of the magazine.

Though its advantages as to rapidity of fire are great, the Committee consider the mechanism of this mitrailleuse to be complicated, and its "assemblage" long and difficult.

On the whole, they had doubts as to its efficiency for field service, which careful experiments alone could determine.

Details.

The system consists of a rectangular frame of cast-iron ($A'A'$, Figs. 1, 2, and 3), the sides of which are connected by three plates or transoms (*aa*, Figs. 2 and 3). The frame is furnished with trunnions, and is capable also of lateral movement on a pivot.

The ten barrels are placed side by side in the frame, their muzzle ends passing through the front transom, while the breech ends are screwed into the middle transom.

Between this middle transom and the rear one there is a parallelopiped box, containing the mechanism (Figs. 1 and 2), which is capable of movement backwards or forwards.†

In it are ten pistons or plungers,‡ corresponding to the barrels. These are of steel, pierced with a channel in which a needle or striker moves freely, and are furnished with an extractor on the right side.

Behind each plunger is a cylindrical cock of steel, with a projecting tenon underneath; and behind the cock, again, a strong spiral spring.

The under surface of the box, or "lock," carries—

1. A "closing cam" (*e*, Figs. 3 and 4), which pivots on an axis, and by means of two curved slits gives reciprocating motion to a couple of bolts (*ff*, Figs. 3 and 4).

When the lock is moved up so that the breech ends of the barrels

* It should be mentioned that in the experiments at Christiana, barrels rifled on the Remington system were used; while at Bourges the barrels had the Berdan rifling (used in the Russian service small-arm). This may account, in some measure, for the different results arrived at.

† This box is termed the "lock" in description given.

‡ The "plungers" resemble very nearly the locks of a Gatling gun.

are closed, these bolts are pushed into corresponding holes in the sides of the frame, and so secure the lock in that position for firing.

2. A "director" (*g*, Figs. 3 and 4); which is a plate, or cam, secured to the lock.

Motion is given to the latter by means of a curved slit in this plate, into which fits a pin on the "directing lever" (*l*, Fig. 3). A portion of this slit is the arc of a circle, concentric with that described by the arm; the remainder is curved, so that as the arm moves from right to left the lock advances, and *vice versâ*.

Upon the brackets, secured to the rear transom, is a "detent" (*h*, Figs. 3 and 4). This is a plate, capable of transverse movement, and having ten teeth bevelled on the left side, and increasing in thickness (to the amount of one-tenth) from right to left.

Its use is to compress (by means of the tenons of the cocks) the whole of the spiral striker springs, and then to release them one by one.

A powerful spring (*i*, Fig. 3), fastened to the transom, presses the detent against the left side of the frame.

The detent, however, is moved to the right, as the lock is drawn back, by the bevelled part of the tenons of the cocks (*d*, Figs. 3 and 4) bearing against the bevelled sides of the teeth, until these tenons pass behind the teeth and bite, when the spring before mentioned drives it sharply to the left again with a loud click.

Movement to the right is afterwards caused by the arm (*l*) pushing the detent to the right, and releasing each tenon (and so the cock and striker) in turn.

The movements of the closing cam, director (with the lock), and detent, are governed by a "directing arm," or lever (*l*), which has a tooth (*T*) at one end moving in the curved slit of the closing cam (*e*), and a projection (*P*) on its upper surface fitting into the groove of the director. The other end is fixed to a strong vertical axis (*m*, Figs. 3 and 4) called the "motive axis," which is secured to the rear transom, and plays a prominent part in the mechanism.

The "carrier," or feeder (*yy*, Figs. 1, 3, and 4), is a plate of copper, having ten longitudinal holes for the cartridge-cases to drop through when extracted, and a similar number of strips on which to carry the cartridges when loading. It is capable of a slight lateral motion, which is given by a forked arm (*s*, Fig. 3) pivoting freely on the motive axis (*m*), and moved to the right or left by a projection on the under surface of the lock.

A bent lever or "handle" (*n*) is fixed to the motive axis (*m*). It can move backwards and forwards under the lock in a horizontal plane, and is the immediate means of putting the whole of the mechanism in motion. To its inner end (where fixed to the axis) is secured a curved arm (*o*), having a pin (*p*) at its extremity. The pin works in a curved slit in an eccentric plate (*E*), by which lateral dispersion is given as follows:—

There is in the eccentric another slit, into which fits the tenon of a

crank (r), capable of being clamped in the slit where required. The outer end of the crank is secured to a horizontal traversing block of brass (q). The block (q) is fastened to the head of the elevating screw, and has a mortice along its interior face, in which slides a projecting tenon on the back of the rear transom of gun-frame.

When, therefore, the handle (n) is moved, together with its arm (o), the pin (p) acts on the eccentric (E), and so upon the crank (r), which would cause the block (q) to slide along the projecting tenon upon rear transom of gun-frame. The block, however, is immoveable laterally, being secured to the elevating screw; consequently the gun-frame moves instead, and lateral dispersion is effected.

By clamping the tenon of the crank (r) at different distances along the groove of eccentric, the angle of dispersion can be regulated as desired.

The carrier is supplied with cartridges by a magazine in the shape of a parallelopiped box having ten vertical divisions, each of which holds 25 cartridges. Grooves are cut in the sides of the divisions at the rear, for the projecting part of the base of the cartridge to slide in. The magazine has a moveable bottom, with ten rectangular holes, through which the cartridges drop on to the carrier ten at a time.

Action.

The action of the mechanism is as follows, supposing the discharge to have been just completed, the lock closing the breech end of the barrels, and being still secured in its place by the two bolts ($f\,f$) :—

1. The handle (n) begins to move to the rear; the projection of arm (l) traverses the concentric part of cam (g), and the lock remains steady. The pin (p) of bent arm (o) travels along the curve of eccentric (E), and the gun-frame therefore moves from left to right until it gains its normal position (as before firing), when the circular part of eccentric groove is reached by p.

The spring (i), acting on detent, drives it from right to left.

2. As the movement continues, the arm (l), by means of tenon (T), acts on the closing cam (e) and withdraws the bolts ($f\,f$), leaving the lock free.

3. At the moment these bolts are withdrawn, the projection (P) engages in the eccentric part of director, and the lock begins to move back, drawing with it the plungers which extract the cartridge-cases.

4. When the plungers have quite left the barrels, the projection on lock bears against the forked arm (s) and so pushes the carrier to the left. At the same time, the tenons of the locks begin to press against the teeth of the detent, carrying the latter to the right.

The empty cartridge-cases fall to the ground. The tenons of the cocks pass behind and bite in the teeth of detent, which is driven to the left by the spring (i).

The handle (n) is now as far back as possible, and the lock in its furthest position from the barrels.

SWEDISH MITRAILLEUR ON THE PALMCRANTZ PRINCIPLE.

FIG. 3.
PLAN AND HORIZONTAL SECTION. $(\frac{1}{5})$

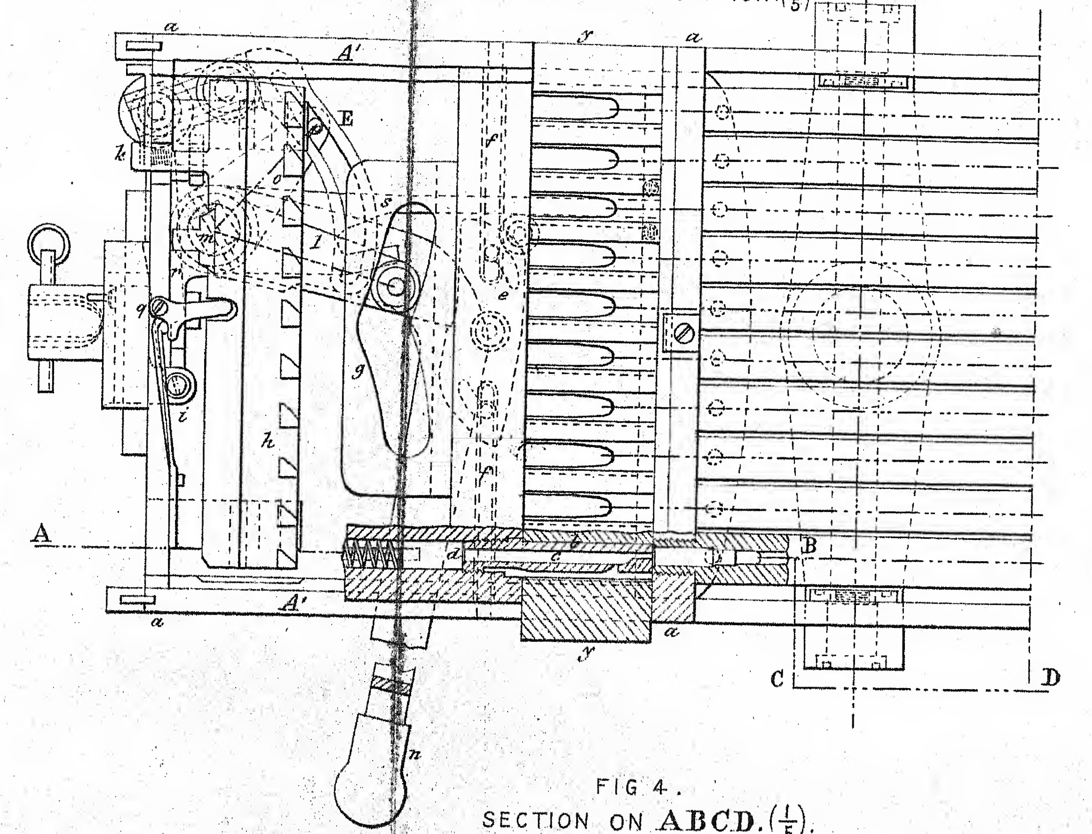
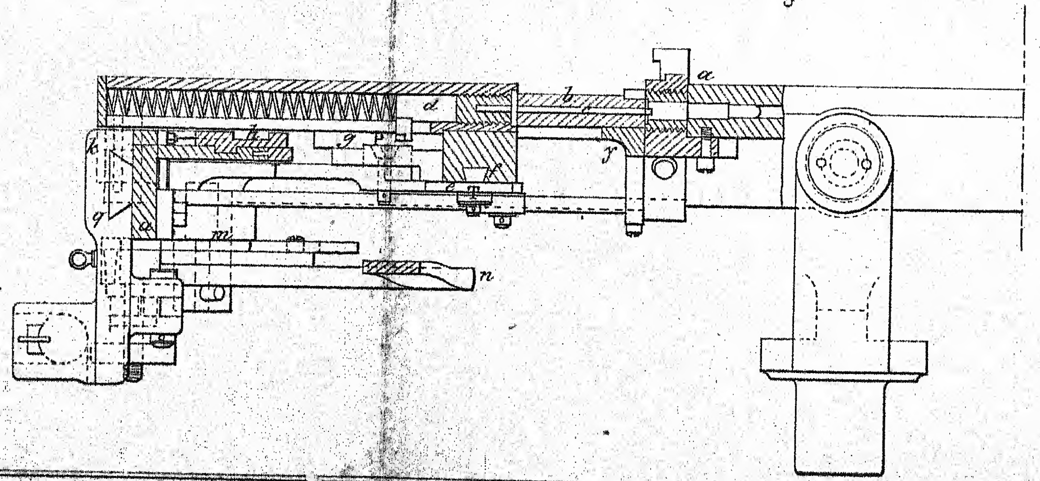


FIG 4.
SECTION ON ABCD. $(\frac{1}{5})$



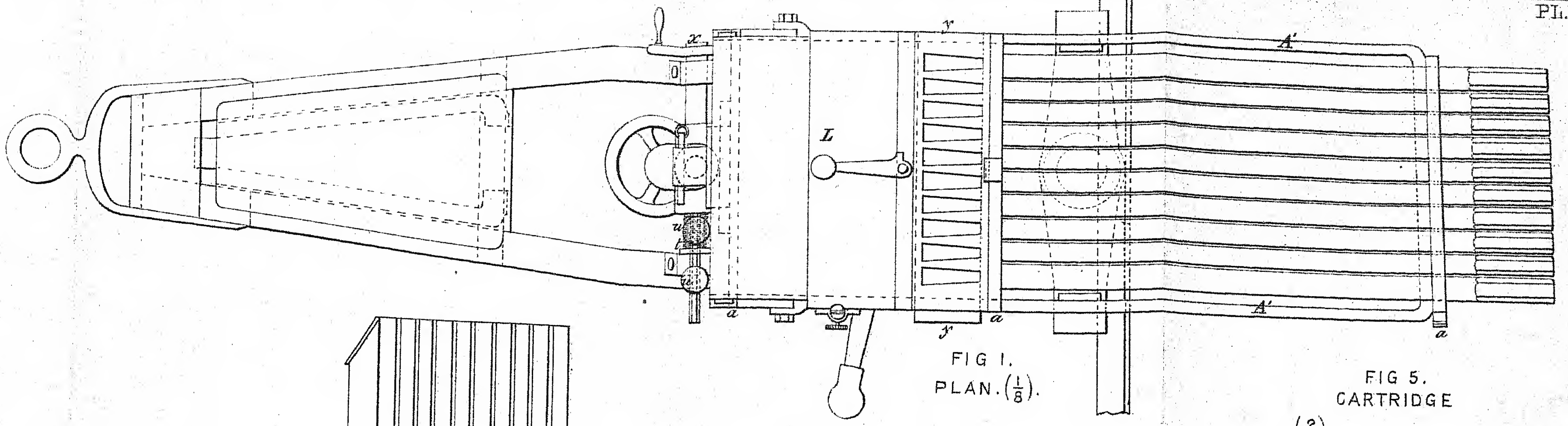


FIG 1.
PLAN. $(\frac{1}{8})$

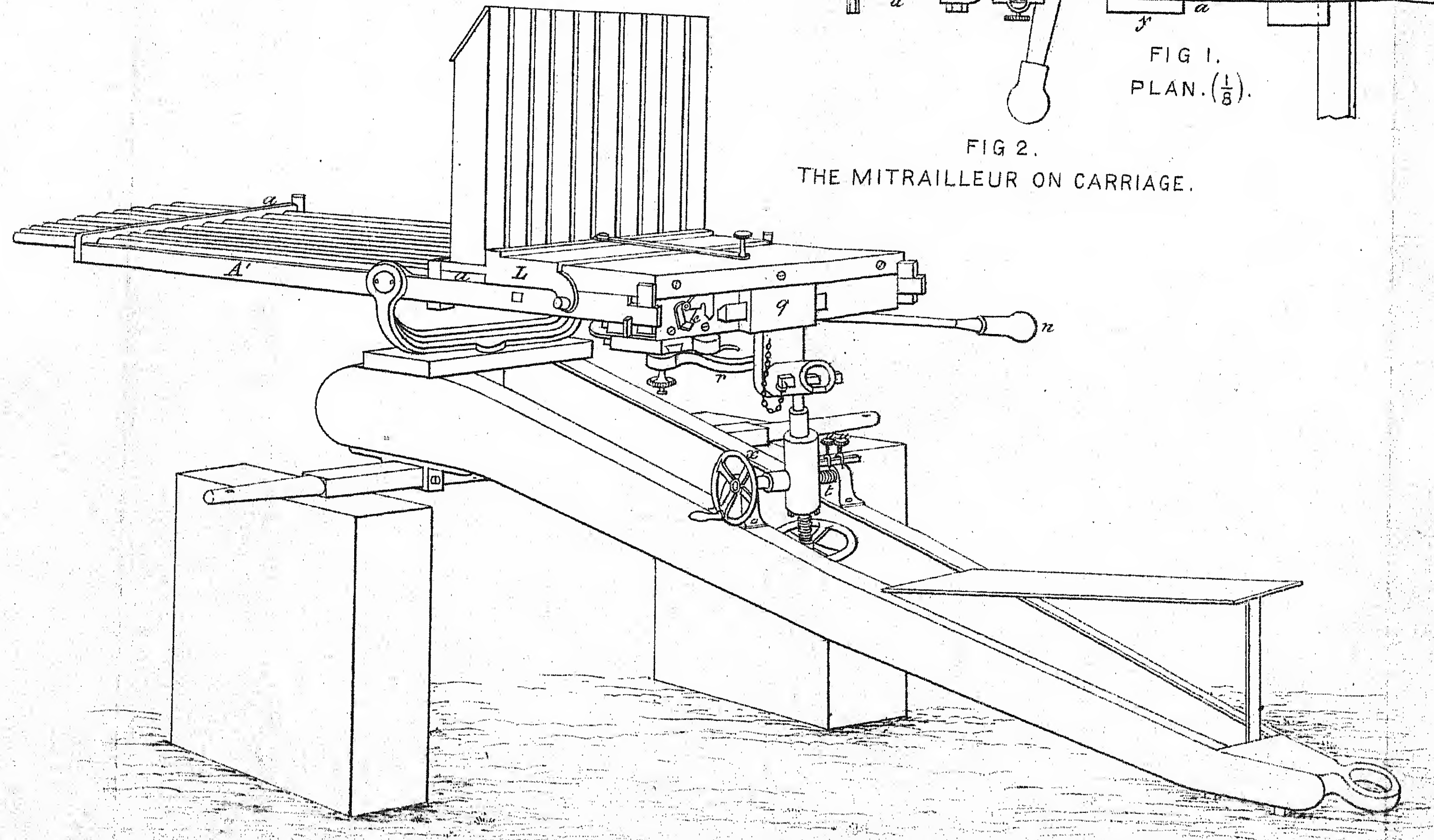
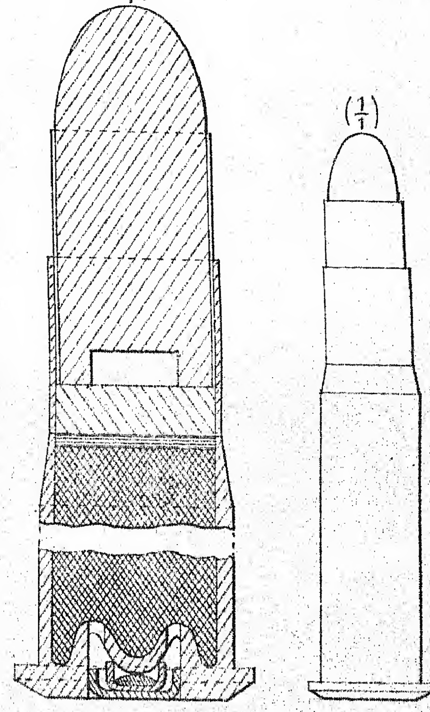


FIG 2.
THE MITRAILLEUR ON CARRIAGE.

FIG 5.
CARTRIDGE



$(\frac{2}{1})$ $(\frac{1}{1})$

The handle next moves forwards with the following effects :—

1. The projection on directing arm acts on director, and moves the lock to the front. The lock, pressing against fork (*s*), drives the carrier to the right, and the cartridges fall on the grooves of the latter.

2. The lock advances to the front, and the spiral springs are compressed by the cocks, which are kept back by the detent. The plungers push the cartridges into the barrels.

3. When the cartridges are quite home, the lock stops, and the pin on directing arm causes the closing cam to drive the bolts (*ff*) into the holes in the gun-frame, so that the breech-closing is complete.

4. The directing arm now begins to act on the detent, carrying it to the right.

Each cock is released in turn from the tooth which retains it, and the striker pertaining to it is driven forward in consequence. As the first one is released, the curved arm (*o*) begins to act on the eccentric (*E*), causing the gun-frame to move in the horizontal plane.

This movement continues while the ten barrels are being fired; its amplitude (as already explained, p. 446) being regulated by the clamping of the tenon of crank (*r*).

The carriage is of iron, consisting of two brackets, on the upper part of which is secured a horizontal plate of iron in which the pivot of the gun-frame works.

The cartridge is of brass, containing a charge of 70 grains of powder, and a cylindro-ogival leaden bullet with hollow base, which weighs 355 grains. With cap, &c., the cartridge weighs 463 grains.

Weight.

	cwt.	qrs.	lbs.
The frame, barrels, &c., with pivot	2	2	6
Carriage, with elevating screw.........................	1	1	8
Two wheels	1	0	20
A full magazine, containing 250 cartridges	0	0	24
Total	5	1	2

THE FELDL REVOLVER CANNON.

(*Used by the Bavarians in* 1870).

This consisted of four parallel barrels, rifled on the Werder system.

Its practical rate of fire was about 300 rounds per minute, and a lateral spread of 28° could be given to it.

	lbs.
The weight of gun was	963
" limber, with 6864 rounds	1451

This gun was drawn by four horses.

The Hotchkiss Revolver Cannon.*

This is a species of mitrailleur meant to fire small percussion shells, weighing (when filled) 570 grammes—about 1½ lbs.

In external appearance it much resembles a Gatling gun, but its mechanism is quite different.

Six barrels of steel pass through two discs, secured to a shaft or axis which is capable of revolution in a rigid frame of wrought-iron. Underneath the system there is, as in the Gatling, an arrangement to allow of the gun pivoting for lateral spread, and also trunnions to allow of movement in a vertical plane.

A spindle, with a worm at the interior end, and at right angles to the main shaft, gears with a pinion at breech end of the latter, so that by turning a handle on the other end of spindle, at the right side of the piece, the axis and barrels are made to rotate.

The thread of the worm is an interrupted one, about one-half of each turn being at right angles to axis of spindle. The system does not therefore rotate during half of each turn, and in this half discharge takes place.

There is only one lock, opposite to which each barrel is brought in turn. This lock consists merely of a striker and a strong spiral spring.

The spring is compressed by a cam, as rotation proceeds; and when a barrel comes round so that its breech end fits against a piece of steel let into breech part of mechanism, the spring is released and the charge exploded.

The full cartridges are pushed into, and the empty ones extracted from, the barrels by a plunger and extractor, secured respectively to the ends of two ratchet bars, which are caused to advance and retire by means of an arm with projecting pin secured to the end of the spindle which rotates the main shaft.

This pin works in a slit-bar, fastened at its centre to the lower ratchet; and so, with the assistance of a loose pinion gearing into both the ratchets, they are made to advance and retreat alternately as the handle goes round.

When the ratchets are in their extreme positions, the slit-bar remains for an instant motionless. The pin does not act for that time, one side of the slit being cut out in a curve. The barrels are not rotating just at that moment, so the cartridge is in one case pushed in, and in the other withdrawn, as one ratchet or the other acts.

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* For the reasons given (pp. 425–6), it does not seem probable that a weapon of this description will be found to answer. Though firing shells, the latter would be too small to penetrate cover at any distance. Still, the idea is somewhat novel, as well as the mechanism, in which ratchet bars play a prominent part.

APPENDIX.

Comparative Equipment of a 9-pr. Field Gun and Gatling Batteries.

9-pr. Field Battery, 6 Guns.

Captain (Major)	1
Second Captain (Captain)	1
Lieutenants	3
Assistant-Surgeon	1
Total	6

Serjeant-Major	1
Quarter-Master-Serjeant	1
Serjeants	3
Corporals	6
Bombardiers	6
Gunners	85
Drivers	81
Trumpeters	2
Farrier	1
Shoeing-Smiths	4
Collar-Makers	2
Wheelers	2
Total	197

Guns	6
Wagons	12
Store wagon	1
Forge wagon	1
General service wagon	1
Store cart	1
Rounds per gun	214

Riding Horses.

Officers'	12
Staff-Serjeants'	2
N.C. officers'	12
Trumpeters'	2
Farrier's	1
Shoeing-Smith's	1
Spare	4
Total	34

Draught Horses.

Guns	48
Ammunition wagons	72
Store wagon	6
Forge	6
General service	4
Store cart	2
Spare	12
	150
Total horses	184

Gatling Battery, 12 Guns, ·45-in. cal.*

Captain (Major)	1
Second Captain (Captain)	1
Lieutenants	3
Assistant-Surgeon	1
Total	6

Serjeant-Major	1
Quarter-Master-Serjeant	1
Serjeants	6
Corporals	6
Gunners	60
Drivers	20
Trumpeters	2
Farrier	1
Shoeing-Smiths	2
Collar-Maker	1
Wheeler	1
Total	101

Gatling guns	12
Small-arm ammunition carts	6
Store wagon	1
Forge and general service wagon combined	1
2208 cartridges carried with each gun	26,496
9000 cartridges in each S. A. A. cart	54,000
	12)80,496
Cartridges per gun	6,708

Riding Horses.

Officers'	12
Staff-Serjeants'	2
N.C. officers'	12
Trumpeters'	2
Farrier's	1
Shoeing-Smith's	1
Spare	4
Total	34

Draught Horses.

Guns	24
Small-arm ammunition cart	12
Store wagon	6
Forge and general service wagon combined	6
Spare	8
	56
Total horses	90

* As recommended by Colonel Wray's Committee.

The total weight of draught of the Gatling is as follows:—

	cwt.	qrs.	lbs.
Gun carriage, when complete	7	0	$7\frac{1}{2}$
Limber, "	5	0	25
Six drums, filled	3	2	0
Total	15	3	$4\frac{1}{2}$

Space occupied by a Battery of six 9-pr. Field Guns, as compared with that occupied by a Battery of twelve Gatlings.

9-pr. Battery.

	Length in yds.	Total.
6 guns, 8 horses................	19	114
12 wagons, 6 horses............	15	180
1 store wagon, 6 horses ...	15	15
1 forge, 6 horses...............	15	15
1 general service wagon, 4 horses..........................	11	11
1 store cart, 2 horses	8	8
Total, in yds.		353

Battery of 12 Gatlings.

	Length in yds.	Total.
12 guns, 2 horses...............	7	84
6 carts, 2 horses...............	7	42
1 store wagon, 6 horses......	15	15
1 general service wagon and forge combined, 6 horses	15	15
Total, in yds.		156

The following tables give a summary of the results obtained from firing, in competition, the pieces mentioned. The practice was carried on by Colonel Wray's Committee in August and September, 1870:—

1st Experiment.—At a line of targets 9 ins. by 9 ins., representing 90 cavalry or 100 infantry. Shrapnel shell only used with the field guns. Firing against time, 2 minutes.

Range, 300 yds.	Weight of ammunition.	No. of hits.	Range, 400 yds.	Weight of ammunition.	No. of hits.	Range, 600 yds.	Weight of ammunition.	No. of hits.	Range, 800 yds.	Weight of ammunition.	No. of hits.	Range, 1000 yds.	Weight of ammunition.	No. of hits.
	lbs.			lbs.			lbs.			lbs.			lbs.	
Small Gatling	53	369	Small Gatling	39	310	Small Gatling	56	522	Small Gatling	30·5	229	9-pr. M.L.	86	294
12-pr. B.L.	121·5	268	9-pr. M.L.	118	236	9-pr. M.L.	75	283	Mitrailleur	25	154	12-pr. B.L.	94·5	218
9-pr. M.L.	107	208	Mitrailleur	30	178	12-pr. B.L.	94·5	142	12-pr. B.L.	82	152	Small Gatling	41·5	62
Mitrailleur	25	171	12-pr. B.L.	121·5	166	Mitrailleur	30	127	9-pr. M.L.	53	118	Martini-Henry	9	47
Martini-Henry	15	74	Snider	9	77	Snider	9	63	Martini-Henry	10	60	Mitrailleur	30	33
Snider	8	63	Martini-Henry	17	68	Martini-Henry	11	52	Snider	10	48			

2ND EXPERIMENT.—At similar targets. Firing deliberate. Shrapnel used with field guns.

Range, 300 yds.	Weight of ammunition.	No. of hits.	Range, 400 yds.	Weight of ammunition.	No. of hits.	Range, 600 yds.	Weight of ammunition.	No. of hits.	Range, 800 yds.	Weight of ammunition.	No. of hits.
	lbs.			lbs.			lbs.			lbs.	
Mitrailleur	25	172	Mitrailleur	25	177	12-pr. B.L.	60	164	12-pr. B.L.	60	203
9-pr. M.L.	45	162	Small Gatling	16	169	Mitrailleur	25	107	Small Gatling	16	183
12-pr. B.L.	60	138	12-pr. B.L.	60	118	9-pr. M.L.	45	78	9-pr. M.L.	45	124
Martini-Henry	14	83	9-pr. M.L.	45	110	Martini-Henry	12	74	Mitrailleur	25	106
Snider	9	74	Martini-Henry	13	90	Snider	9	63	Martini-Henry	12	85
			Snider	8	61				Snider	8	62

3RD EXPERIMENT.—At three rows of targets, 20 yds. apart. Shrapnel and segment shell with field guns. Firing against time, 2 minutes.

Range, 1200 yds.	Weight of ammunition.	No. of hits.	Range, 1400 yds.	Weight of ammunition.	No. of hits.	Range, 2070 yds.	Weight of ammunition.	No. of hits.	Range, 2100 yds.	Weight of ammunition.	No. of hits.
	lbs.			lbs.			lbs.			lbs.	
Small Gatling	28	204	Med. Gat. 0·65-in.	89	236	Med. Gat. 0·65-in.	127	164	12-pr. B.L. segment	108	73
Mitrailleur	50	201	12-pr. shrap. B.L.	60	224	12-pr. B.L. seg.	72	115	9-pr. M.L. shrapnel	63	72
12-pr. seg. B.L.	72	173	9-pr. shrap. M.L.	54	178	Large Gatling	198	99	9-pr. M.L. segment	54	52
9-pr. seg. M.L.	54	99	Small Gatling	47	104	9-pr. M.L. segment	54	60	Med. Gat. 0·65-in.	114	45
9-pr. shrap. M.L.	54	92	12-pr. seg. B.L.	84	102	12-pr. B.L. shrapnel	72	41	12-pr. B.L. shrapnel	60	29
Martini-Henry	12	84	Large Gatling	212	99	9-pr. M.L. shrapnel	54	35	Large Gatling	100	12
12-pr. shrap. B.L.	60	78	9-pr. seg. M.L.	63	70						
			Mitrailleur	37	68						

4TH EXPERIMENT.—At 134 dummies, in loose order, representing infantry retiring. Front 98 yds., average depth 35 yds. Firing at three positions, with unknown ranges. Shrapnel shell only used with field guns.

1st position.	Weight of ammunition.	No. of hits.	2nd position.	Weight of ammunition.	No. of hits.	3rd position.	Weight of ammunition.	No. of hits.
	lbs.			lbs.			lbs.	
Small Gatling...	39	312	Small Gatling...	63	162	Small Gatling...	63	177
Mitrailleur	45	122	Mitrailleur	45	83	9-pr. M.L.	53	47
9-pr. M.L.	53	74	12-pr. B.L.	67·5	82	12-pr. B.L.	67·5	39
Martini-Henry	16	65	Martini-Henry	14	49	Martini-Henry	12	38
Snider	5	51	9-pr. M.L.	53	34	Mitrailleur	55	9
12-pr. B.L.	67·5	29	Snider	2	24	Snider	·687	7

NOTE.—Six Guardsmen, armed with the Martini-Henry rifle, and a similar number with the Snider, were pitted against the guns.

Results of Experimental Firing carried on in October 1873, *at Fort Monroe, Virginia, by a Board of U.S. Officers, General Gillmore President, the pieces tried being* 0·42-*in. calibre Gatling Gun*, 4·62-*in. calibre Bronze Gun* (12-*pr. Napoleon*), *and* 8-*in. Siege Howitzer.*

Canvass target, 9 ft. high by 45 ft. wide. At 500 yds.

Pieces and ammunition employed.	No. of shots fired.	No. of hits.
0·42-in. calibre Gatling gun, firing solid shot;* time, 1 min. 30 secs. ...	600	557
12-pr. Napoleon, with time fuze, firing spherical case containing 82 lead balls 0·69 in. diameter; 7 rounds fired; time, 1 min. 30 secs.	574 lead balls	55
12-pr. Napoleon, 6 rounds fired; time, 1 min. 30 secs....................	492 lead balls	184
8-in. siege howitzer, with time fuze, firing spherical case containing 486 lead balls 0·69 in. diameter; 4 rounds fired; time, 1 min. 30 secs.	1944 lead balls	112
At 800 yds.		
0·42-in. calibre Gatling gun, firing solid shot, deliberately (aim unknowingly too high)	600	106
0·42-in. Gatling gun, firing solid shot, deliberately	600	534
12-pr. Napoleon gun, with time fuze and spherical case, as above; 7 rounds fired deliberately	574 lead balls	3
12-pr. Napoleon gun, with time fuze and spherical case as above; 7 rounds fired deliberately	574 lead balls	35
8-in. siege howitzer, with time fuze and spherical case, as at 500 yds.; 4 rounds fired deliberately	1944 lead balls	0

* The ammunition used with this Gatling was "Berdan's centre-fire metallic case cartridge."

Weight.

	grs.
0·42-in. calibre projectile	370
Metallic case and lubricant	163
Powder (Hazard's Gatling powder, No. 1)	77
	610

Comparative Effect of Field Guns (12 *and* 9-*pr.*) *and small Mitrailleuses, at different ranges, summed up, and weight of Ammunition expended shown.*

1st Experiment. 2nd Experiment.

Small Gatling.		Mitrailleur.		12-pr. B.L.		9-pr. M.L.		Small Gatling.		Mitrailleur.		12-pr. B.L.		9-pr. M.L.	
lbs.	hits.	lbs.	hits.	lbs.	hits.	lbs.	hits.	lbs.	hits.	lbs.	hits.	lbs.	hits.	lbs.	hits.
53	369	25	171	121·5	268	107	208	—	—	25	172	60	138	45	162
39	310	30	178	121·5	166	118	236	16	169	25	177	60	118	45	110
56	522	30	127	94·5	142	75	283	—	—	25	107	60	164	45	78
30·5	229	25	154	82·0	152	53	118	16	183	25	106	60	203	45	124
41·5	62	30	33	94·5	218	86	294	—	—	—	—	—	—	—	—
220	1492	140	663	514	946	439	1139	32	352	100	562	240	623	180	474

3rd Experiment.								4th Experiment.							
Small Gatling.		Mitrailleur.		12-pr. B.L.		9-pr. M.L.		Small Gatling.		Mitrailleur.		12-pr. B.L.		9-pr. M.L.	
lbs.	hits.	lbs.	hits.	lbs.	hits.	lbs.	hits.	lbs.	hits.	lbs.	hits.	lbs.	hits.	lbs.	hits.
28	204	50	201	132	251	108	191	39	312	45	122	67·5	29	53	74
47	104	37	68	144	326	117	248	63	162	55	83	67·5	82	53	34
—	—	—	—	—	—	—	—	63	177	55	9	67·5	39	53	47
75	308	87	269	276	577	225	439	165	651	145	214	202·5	140	159	155

Comparison of Total Effects v. *Weight of Ammunition expended, at ranges under* 1400 *yds.* (*Vide* No. 1 and 2 Experiments).

The small Gatling gun,	weighing	3	cwt.,	expended 492	lbs. of ammn.	and scored	2803	hits.
" Montigny mitrailleur	"	3	"	472	"	"	1708	"
" 12-pr. B.L.	"	8	"	1232·5	"	"	2286	"
" 9-pr. M.L.	"	8	"	1013	"	"	2207	"

Comparison of Field Guns (12-*pr. and* 9-*pr.*) *with the large and medium Gatling Guns, at ranges exceeding* 1400 *yds.; showing the weight of Ammunition expended.* (See No. 3 Experiment).

The large Gatling gun,	weighing	6	cwt.,	expended 298	lbs. of ammn.	and scored	111	hits.
" medium "	"	5	"	241	"	"	209	"
" 12-pr. B.L. gun	"	8	"	312	"	"	258	"
" 9-pr. M.L. "	"	8	"	225	"	"	219	"

Note.—The practice of the guns on this occasion was unusually bad, and the experimental segment shell of the 9-pr. M.L. most imperfect.

June, 1874.

ANNUAL REPORT

AND

ABSTRACT OF PROCEEDINGS OF A GENERAL MEETING OF THE ROYAL ARTILLERY INSTITUTION, HELD ON MAY 28, 1874.

COLONEL R. P. RADCLIFFE, R.A., IN THE CHAIR.

AT the termination of the financial year, the Committee place before the General Meeting of the Members of the R.A. Institution—

1. A *précis* of the work done by them.
2. A notice of the lectures given in the Theatre of the Institution.
3. An account of the additions to Library and Museum, by gifts from the Government and Members, and also by purchase.
4. An account of the use made of the Class Rooms, Laboratory, Photographic Establishment, &c.
5. A statement of the financial condition of the Institution.

1. The Committee have met regularly on the first Thursday in every month throughout the year, transacted the ordinary business, and decided upon the publication of the papers written for insertion in the "Proceedings"—which have been numerous, and of great interest. They trust that, should the addition to the Printing Establishment be carried out, the number of papers circulated annually will be greater. A list of those published will be found in Appendix, Table A. The thanks of the members are due to the contributors.

Several very interesting "Translations" have been printed. A list of them, marked B, will also be found in Appendix. The Committee trust that members will continue their contributions. Several officers have promised to review the foreign military publications, and it is hoped these reviews will assist members at out-stations who may be desirous of becoming acquainted with the progress of artillery in other nations.

With a view to the comfort of members, and to enable them to read without interruption the scientific and other publications obtained for the R.A. Institution, the Committee have converted the room hitherto set apart for the use of Committees into a "Silent" Reading Room, and have caused to be moved into it the greater number of the books from the former Library. This measure has the additional advantage of securing the proper arrangement and safety of the books, which hitherto had not been under proper surveillance, and renders the former Library available as a Class Room—a purpose for which it is well suited.

Since the publication of the last Annual Report, the Library

Catalogue has been printed and circulated; many additions thereto have also been made, by presentation and purchase.

The maps in possession of the Institution have been arranged, and are now readily accessible to members wishing to consult them.

The Committee have also caused the "Handbook for Field Service" to be revised, to some extent, so as to render the remaining copies of the last edition more useful to members. They abstained from the issue of a fresh edition, there being still a large number of copies in stock, and a great portion of the work being of a character which does not change materially with time. It was considered that the wants of the regiment would be met, for the present, by bringing as far as possible up to date those pages which were considerably altered by the changes in ordnance, &c., since 1867—the date of the publication of the fourth edition.

The Committee here take the opportunity of remarking that they have been unable to bring out the various publications as rapidly as it was their wish to do, in consequence of the limited and bad accommodation of the Printing Establishment. An item was inserted in the Estimates for the present year to provide a more suitable building for the purpose. It was thrown out, under a misapprehension; but has been re-inserted for next year, and it is hoped will be approved.

They trust that members will continue to contribute original matter for the "Proceedings" as liberally as heretofore.

2. The Lectures given during the year, though, from various causes, not so numerous as the Committee had intended, were, however, of a very interesting nature. The following officers have voluntarily exerted themselves for the good of the members, lecturing upon the subjects opposite their names:—

Major F. Duncan, M.A., &c., &c.	"The Battle of Inkermann: another chapter in the History of the Royal Artillery."
Captain C. O. Browne	"The forthcoming Transit of Venus."

The Committee also secured the services of the following gentlemen, who have given their audiences the benefit of their studies:—

Professor W. Barrett, F.C.S., &c., &c.	"Recent Discoveries in Magnetism and Electricity."
W. Carpenter, Esq., M.D., &c., &c. ...	"On the Physical Geography of the Deep Sea."

3. There have been many additions, through the kindness of the Secretary of State for War and members of the Institution and Societies, to the Library of the R.A. Institution, and also to the Natural History Museum. The Committee trust that their brother officers will not fail to remember that there are still many common specimens, both British and foreign, which are not in the latter, and which they hope soon may be presented.

A list of the purchases for and presentations to the Library will be found in Appendix, marked C; and of those to the Museum, marked D.

4. The Committee are glad to be able to report that the Classes for French and German have been more than usually attended, that a Mathematical Class has been formed, and that the number of members who have received instruction in drawing has been more than usually great.

The changes in the garrison have been so many during the past year, that only a few of the members have been able to avail themselves of the opportunities of instruction, not only in the chemistry of warlike stores but also in the Laboratory, which have been open to them.

The equatorial telescope being now in excellent order and adjustment, the balance due to the maker will be at once paid. It is proposed to render this instrument more perfect by the addition of a solar eye-piece and a star spectroscope.

The Observatory is open for the use of members on three days in the week, and on such other occasions as they may wish, by giving previous notice.

All the instruments in possession of the Institution are in good order, and ready for the use of members.

In compliance with a wish expressed by the Astronomer Royal, Sir G. B. Airey, K.C.B., &c., &c., the Committee have granted to him the loan of the portable transit instrument, for use at the approaching transit of Venus.

5. With reference to the financial state of the R.A. Institution, the Committee have the pleasure of reporting that, notwithstanding the large sum paid for the telescope, a general credit of £2376 7s. 8d. is shown in the annexed tabular statement, as against £1893 6s. 9d. last year.

Of this sum, the Committee propose to invest a sufficient amount to bring the stock possessed by the Institution (now £1686 5s. 7d.) to £2000, and to expend as much as may be necessary in re-furnishing the Theatre and Library, and adding to the books and maps.

The Committee consider it, however, to be their duty to bring to the notice of the General Meeting the fact that £121 is due for subscriptions for past years—a fact they believe chiefly due to members ordered to India and other foreign stations not leaving instructions with their agents to pay the annual subscription. As this, however, has a marked influence upon the amount of cash at their disposal during the year, they hope that this notice may have the effect of very considerably lessening these arrears.

A detailed account of the expenditure and receipts during the year, and a Dr. and Cr. statement, will be found in Appendix.

A Trustee being required for the funds of the Institution, in consequence of the death of Major-General A. J. Taylor, the Committee requested Major-General F. M. Eardley-Wilmot, F.R.S., to undertake the duties, and are glad to be able to report his acceptance of them.

GENERAL ABSTRACT

OF THE

INCOME AND EXPENDITURE OF THE ROYAL ARTILLERY INSTITUTION,

From 1st *April*, 1873, *to* 31st *March*, 1874.

Expenditure.

		£	s.	d.	£	s.	d.
Printing	Wages	151	9	4	418	11	2
	Paper and Materials	216	17	8			
	Type and General Plant	5	13	2			
	Woodcuts	10	14	0			
	Lithography	33	17	0			
R.A. Institution Prize Essay					10	10	0
Chemistry					0	0	0
Photography	Salary	104	0	0	208	2	6
	Photographs	104	2	6			
Classes	Drawing	102	7	6	110	15	6
	Mathematics	8	8	0			
Lectures					23	16	0
Taxidermy					20	0	6
Library, and Books for Sale					266	16	9
Museum					35	9	0
Instruments					286	6	1
Carpenter	Wages	18	0	8	99	7	0
	Materials, &c.	81	6	4			
Furniture and Repairs					13	7	2
Subscriptions	To Societies	4	4	0	5	5	0
	Refunded	1	1	0			
Stationery					126	5	2
Postage and Parcels					59	11	0
Incidental					67	4	4
Wages to Clerks and Orderlies					139	18	5
War Office Photographs and Lithographs					21	10	8
Premiums for Fire Insurance	R.A. Institution in £5000	12	10	0	13	18	6
	R.A. Observatory in £1000	1	8	6			
Cash in hand, 31st March, 1874,	Secretary	197	7	10	433	2	8
	Messrs. Cox & Co.	235	14	10			
					£2359	17	5

Income.

		£	s.	d.	£	s.	d.
Cash in hand, 31st March, 1873					96	1	6
Printing					227	19	0
R.A.I. Prize Essay					10	10	0
Chemistry					0	5	0
Photography					174	16	1
Classes	Drawing	66	3	7	71	14	7
	Mathematics	5	11	0			
Lectures					0	0	0
Taxidermy					23	0	6
Books sold					207	13	4
Museum					0	0	0
Instruments					0	0	0
Carpentry, Wood, and Picture Framing					57	14	0
Furniture and Repairs					0	0	0
Subscriptions	Entrance	96	0	0	1197	11	6
	1871–2	1	6	0			
	1872–3	15	10	0			
	1873–4	1075	7	6			
	In Advance	9	8	0			
Stationery					175	8	6
Postage and Parcels					31	6	2
War Office Photographs and Lithographs					35	18	1
Dividends on £1686 5s. 7d. Consols					49	19	2
					£2359	17	5

DEBTOR AND CREDITOR ACCOUNT FOR THE YEAR ENDING 31st MARCH, 1874.

Dr.

	£	s.	d.
Mr. J. Gould, Balance of Account for "Birds of Australia"	50	15	0
Mr. Howard Grubb, Balance of Account for Telescope	29	10	0
Printing Paper, Wood Engraving, &c.	21	0	4
Drawing Instruction	28	17	6
Instruction in Mathematics	6	6	0
Photography	18	4	8
Taxidermy	1	2	6
Books	52	3	7
Museum	7	10	0
Instruments	1	12	0
Wood, Picture Framing, &c.	8	17	11
Repairs	1	1	9
Stationery	4	2	1
Incidental	1	2	5
Balance Creditor	2376	7	8
	£2608	13	5

Cr.

		£	s.	d.	£	s.	d.
Balance Cr.	Cash in hand	433	2	8	1984	10	2
	Consols Stock (at 92)	1551	7	6			
Value of Stock.	Books for Sale	20	0	0	229	1	6
	Stationery	25	0	0			
	Printing Paper	18	11	10			
	"Handbooks" (unbound)	38	12	11			
	"Kane's Lists" do.	106	16	9			
	Chemicals in Laboratory	20	0	0			
Owing by Members and others for	Printing	22	4	0	395	1	9
	Photography	49	3	5			
	Classes	12	12	10			
	Taxidermy	2	13	0			
	Books	97	14	8			
	Carpentry	5	19	10			
	Subscriptions	121	0	0			
	Stationery	52	11	10			
	Postage and Parcels	28	2	5			
	War Office Photographs and Lithographs	2	19	9			
					£2608	13	5

Examined and found correct,

S. E. GORDON, Lt.-Col. R.A., & Col., President Sub-Committee.

W. H. KING HARMAN, Capt. R.A., Secretary and Treasurer.

Woolwich, May 27th, 1874.

The subject for the Prize Essay this year was the "Duties and Position of the Artillery of the Advanced Guard of an Army in the Field." Eleven essays were received, and submitted to the decision of Major-Gen. Sir E. C. Warde, K.C.B., Major-Gen. C. D'Aguilar, C.B., and Major C. B. Brackenbury, who had kindly consented to act as referees. The medal was awarded to Lieut. S. C. Pratt.

In the opinion of the referees, the essays bearing the mottoes

"Meliora speramnus,"
"Ready, aye ready!"
"Esse quam videre,"

also possessed considerable merit.

The number of members of the Institution is now 1441, being an increase during the year of 56. (*Vide* Appendix E.)

The following changes in the Committee have taken place during the year:—

Colonel A. F. F. Connell, replaced Colonel A. T. Cadell.
" M. B. Forde, " " G. Leslie.
Lieut.-Colonel F. Close, " Lieut.-Colonel A. W. Drayson.
" W. Stirling, joined the Committee.
Major E. Keate, replaced Major J. S. Stirling.

The following officers retire, in accordance with Rule V.:—

Colonel T. W. Milward, C.B.	Lieut. E. H. O'Malley.
Major F. Duncan.	Major S. H. E. Chamier, R.H.A.

Captain R. S. Muir Mackenzie.

The following are elected:—

Colonel G. Rotton.	Major A. H. King, R.H.A.
Major E. Staveley.	Captain C. C. Saxton.
Lieut. E. G. H. Bingham.	Surg.-Major S. H. Fasson.

Left the Garrison during the year:—

Colonel A. T. Cadell.	Lieut.-Colonel A. W. Drayson.
" G. Leslie.	Major J. S. Stirling.

Captain R. S. Muir Mackenzie.

The following resolutions were proposed :—

1. *Proposed by Colonel Radcliffe, seconded by Lieut.-Colonel Bruce, and carried :—*

"That the Report be adopted."

2. *Proposed by Lieut.-Colonel Bruce, seconded by Colonel Gordon, and carried :—*

"That a Statement of the Accounts of the R.A. Institution for the past year, be in future laid upon the table in the Reading Rooms R.A. Institution and R.A. Library, fourteen days before the General Meeting."

3. *Proposed by Colonel Radcliffe, seconded by Colonel Field, and carried :—*

"That a circular be sent to all officers who may be in arrear of subscription, requesting them to inform the Secretary in what manner their subscriptions would be paid for the future, as they appear no longer to have an account with Messrs. Cox and Co."

4. *Proposed by Colonel Radcliffe, seconded by Colonel Field, and carried :—*

"That a Memo. be circulated with the next number of "Proceedings," informing members that the price of "Kane's List" has been reduced, for the present, to two shillings and sixpence for a bound, and one shilling for an unbound copy."

5. *Proposed by Colonel Field, seconded by Captain Cameron, and carried :—*

"That, as it is desirable that the papers should be circulated as soon as possible after their approval, the Committee are requested to consider if some steps cannot be taken for the publication of the "Proceedings" monthly."

6. *Proposed by Colonel Field, seconded by Colonel Gordon, and carried :—*

"That, in addition to the new catalogue of the Library recently issued, the original MS. catalogue should be kept up to date."

7. *Proposed by Colonel Field, seconded by Colonel Connell, and carried unanimously :—*

"That the thanks of the Meeting be voted to the Chairman."

APPENDIX.

A.

List of Papers published in the "Proceedings" during the past year.

An Endeavour to Determine a Tactical Basis for the Artillery of England. A Lecture delivered at the R.A. Institution, Woolwich, Jan. 3, 1873, by Major H. Le G. Geary, R.A.

The German Artillery in 1870–71. Translated from the French by Captain Hime, R.A.

The Calibre of Field Guns. By Captain W. H. Noble, R.A., M.A.

Details of the Field Artillery of the principal Foreign European States.

Annual Report and Abstract of Proceedings of a General Meeting of the Royal Artillery Institution, held on June 2, 1873. Colonel J. W. Domville, R.A., in the Chair.

The Mobility of Field Artillery; Past and Present. By Captain Hime, R.A., F.S.S. (No. V.)

On the Principles which Regulate the Efficiency of Artillery Projectiles. By Lieut. E. Clayton, R.A. The R.A. Institution Prize Essay of 1873.

On Construction of Elevator, Moncrieff Carriage. By the Rev. J. White, M.A., Instructor in Mathematics, R.M. Academy.

Note on the Expenditure of Ammunition by the German Field Artillery in 1870–71. By Captain Hime, R.A., F.S.S.

Graphical Solution of Problems on Artillery Machines. By Major W. H. Wardell, R.A., Instructor in Mathematics and Mechanics, R.M. Academy.

Principles of Construction of Field Artillery Carriages.
Principles of Construction of Transport Carriages. } By Capt. W. Kemmis, R.A.

Notes on Artillery Tactics. By Lieut.-Col. W. J. Williams, C.B., R.A.

On the Influence of the Wind on the Flight of Projectiles. By Major E. Maitland, R.A.

Report of Telescope Sub-Committee, and a short Description of the Instrument (by the Maker, H. Grubb, Esq., of Dublin).

The Mobility of Field Artillery; Past and Present. By Captain Hime, R.A., F.S.S. (Conclusion).

On the Pressure required to give Rotation to Rifled Projectiles. By Captain A. Noble, F.R.S., &c. (late R.A.)

B.

List of "Translations" published during the year.

On the Employment of Artillery. Communicated by Lieut.-Colonel W. E. M. Reilly, C.B.

The Characteristics of Modern Battles. Translated from the German by Captain Hime, R.A.

Report of Comparative Experiments between the French Field Gun (Canon de 4 Rayé), the English 9-pr. (bronze and wrought-iron), and Vavasseur's Guns (two

systems), carried on by the French Commission of Experiments at Bourges. Translated from the "Revue d'Artillerie" by Lieut. Liddell, R.A.

Continuation of the Comparative Experiments between the Woolwich Gun and the Vavasseur Ribbed Gun. (Précis from the Original Report of the Bourges Committee). Translated and Précis made by Lieut. George O'Malley, R.H.A.

List of "Short Notes" published during the year.

Continuation of the Plan for Carrying the Detachments with Field Artillery. Communicated by Major S. Penny, R.A.

Royal Laboratory Screw Precussion Fuze, G.S. (General Service). Communicated by Captain J. Sladen, R.A.

Fuze, Time, Wood, R.M.L. Ordnance. Communicated by Captain J. Sladen, R.A.

Description of the Swiss Pile-driving Machine. Communicated by Major Downes, R.A.

New Wrought-iron Field Artillery Carriages. Communicated by Captain W. Kemmis, R.A.

C.

Presentations to the Library, &c.

Proceedings of the Institution of Mechanical Engineers for October, 1872, January and July, 1873	The Council of the Institution.
Journal of the Royal United Service Institution, Vol. IX.; Nos. 70, 71, 72, 73, 74, and 75, Vol. XVII.	The Council of the Institution.
Proceedings of the Scientific Meetings of the Zoological Society of London for 1872, Part III.; Parts I. and II., 1873	The Council of the Society.
Proceedings of the United Service Institution of India, Nos. 10, 11, 12, and 13, Vol. III.	The Council of the Institution.
Charter, Bye-Laws, and List of Members of the Institution of Civil Engineers	The Council of the Institution.
Proceedings of the Royal Geographical Society, Nos. 3, 4, 5, Vol. XVII.; No. 1, Vol. XVIII. Journal of the Royal Geographical Society, Vol. XLII.	The Council of the Society.
Monthly Notices of the Royal Astronomical Society, Nos. 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, Vol. XXXIII.; Nos. 1, 2, 3, and 4, Vol. XXXIV.	The Council of the Society.
Examination Papers R.M. Academy, February, June, and October, 1873	The Governor, R.M. Academy.
Text-Book of the Construction and Manufacture of Rifled Ordnance; Second Edition	Captain F. S. Stoney, R.A.
The Theory of Modern Skirmishing. By Major A. Schmid	Captain E. F. Chapman, R.A.
Italian Artillery Journal for 1872. Part I., official; Part II., non-official	The Italian Government.
Institutions Militaires de Vegece	Captain H. W. L. Hime, R.A.

Plan of the Works carried on against Sebastopol; drawn during the siege by Major Gordon, R.E. Commission de Experiences de Bourges, &c. ... Experiences comparatives entre des canons de 4 rayés de campagne des canons Anglais de 9 livres en bronze ou en acier (de Woolwich), et de canons systeme Vavaseur....................	Col. S. E. Gordon, C.B., R.A.
Historical Representation of Iron Plates and Iron Constructions generally used in Fortresses, with sketches of the best projectiles against iron plates and armour-plated ships. By E. G. F. Von Aicha............................	The Author.
A Concise Text-Book on Military Law. By Captain A. Ford, R.A.	The Author.
Iron-cased Ships of France; dimensions, cost, armament, &c., 1870	Admiral Sir A. Cooper Key, K.C.B.
Explosive Agents applied to Industrial Purposes. By F. A. Abel, F.R.S.	The Author.
Heavy Rifled Ordnance; Speech of Mr. Hick, M.P., in the House of Commons, 23rd June, 1873..	Bashley Britten, Esq.
The Tactics of the Three Arms, as modified to meet the requirements of the present day. A lecture delivered at the R.U.S. Institution by Captain H. Brackenbury, R.A..................	The Lecturer.
Volcanic Energy; an attempt to develop its true origin and cosmical relations. By R. Mallet, A.M..	The Author.
Contributions to Terrestrial Magnetism. By General Sir E. Sabine, K.C.B., V.P.R.S......	The Author.
Lectures on Artillery Subjects, addressed to the Officers of the Auxiliary Artillery..............	The Council National Artillery Association.
Washington Astronomical and Meteorological Observations, 1870 .... Washington Catalogue of Stars, 1845 to 1871... Zones of Stars, observed at the United States Naval Observatory with the mural circle, from 1846 to 1849 .... Zones of Stars, observed at the United States Naval Observatory with the meridian transit instrument, from 1846 to 1849 .... Results of Observations made at the United States Naval Observatory with the transit instrument and mural circle, from 1853 to 1860 .... Report of the Difference of Longitude between Washington and St. Louis. By W. Harkness On the Right Ascensions of the Equatorial Fundamental Stars, and the Corrections necessary to Reduce the Right Ascensions of different Catalogues to a mean homogeneous system. By Simon Newcomb, U.S. Navy ...	Rear-Admiral B. F. Sandes, United States Navy, through Smithsonian Institution.
Lightning and Lightning Conductors. By W. H. Preece, Esq., M.I.C.E..............................	The Author.
The History of the Royal Artillery. Vol. II. By Captain F. Duncan, R.A., M.A., D.C.L., &c.	The Author.

Special Committee on Gun-Cotton. Storage and Transport of Gun-Cotton. Second Report ...	
Report on the French Artillery, 1873. By Colonel E. Reilly, C.B., R.A.	
Map of Ashantee and Gold Coast.................	
Sketch Map of Gold Coast. Two sheets	
Revised Map of Gold Coast. Half sheet........	
Map of Ashantee and the Gold Coast. Three sheets	
The Franco-German War, 1870–71, 1st part, 3rd section. Translated from the German by Captain F. C. H. Clarke, R.A.	
The Armed Strength of Austria. Compiled by Captain W. S. Cooke, 22nd Regt. Part. I....	
A Précis of Modern Tactics. By Major R. Home, R.E.	
Manual of Artillery Exercises, 1873	
Report on Experiments undertaken to test the comparative merits of the Rifled Canon de 4, English Guns (9-prs. bronze and steel) made at Woolwich, and the Vavasseur Gun	The Secretary of State for War.
L'Armement et le Tir de l'Infanterie. Par J. Capdevielle, Lt.-Col. au 33e d'Infanterie. Atlas	
Four R.L. Lithographs	
Four R.C.D. 〃	
Twenty W.O. Photographs	
9-pr. and 16-pr. Rifled M.L. Batteries; Weight of Shafts on Horse's Back	
Extracts from the Proceedings of the Department of the Director of Artillery. No. 4, Vol. X.; Nos. 1, 2, and 3, Vol. XI.	
Duplicate Set of Kriegs-spiel Maps, in seven parts..	
Austrian Handbook for Field Artillery...........	
Lectures delivered in the School of Military Engineering, Chatham.	
Subjects:—	
Chatham Dockyard Extension Works. By G. A. Bernays, Esq., C.E.	The Commandant, School of Military Engineering, Chatham.
Rough Notes of eleven Lectures on the use of certain Electrical Apparatus	
Notes on the Building Trades and Building Construction. By Captain H. C. Seddon, R.E.	
Remarks on the Chemical Analysis of Samples of Soil from Bermuda	Major-General J. H. Lefroy, C.B., R.A.
Rifling for Heavy Guns. By Captain J. P. Morgan, R.A.	The Author.
The Construction and Manufacture of Rifled Guns. By Captain C. Jones, R.A.	The Author.
Notes on Field Artillery Projectiles. By Captain J. R. Oliver, R.A.	The Author.
Greenwich Magnetical and Meteorological Observations, 1871	The Astronomer Royal.

Professional Papers of the Corps of Royal Engineers. Vol. XXI., 1873 (2 copies)	The Editor.
Russian Artillery Journal. No. 12, 1872; Nos. 1, 3, 4, 5, 6, 7, 8, 9, 10, 11, and 12, 1873...... Recueil Militaire. Part IV., 1872; and Parts I., II., and III., 1873	The Russian Government.
The Artillerist's Manual and British Soldier's Compendium. Eleventh Edition. By Major L. Griffiths and Captain F. Duncan, R.A., D.C.L., &c.	Captain F. Duncan, R.A.
Hart's Army List for January and April, 1873...	R.A. Library.
Plans of the new Danish Artillery *Matériel*. Nos. 58–60	The Officers Royal Danish Artillery.
On the Relation of the Parish Boundaries in the South-East of England to Great Physical Features, particularly to the Chalk Escarpment. By W. Topley, F.G.S.................	The Author.
Smithsonian Contributions to Knowledge. Vol. XVIII. .... Report of the Chief Signal Officer, United States War Department, 1872 .... Geological Survey of Montana, Idaho, Wyoming, and Utah, 1872 .... Smithsonian Report, 1871 .... Smithsonian Miscellaneous Collections. Vol. X.	The Council, Smithsonian Institution.
Suggestions for Supplementing our Coast Defences on the Moncrieff System, in harmony with the new District Organisation. By Major Moncrieff, F.R.S. .... Further Observations on the Moncrieff System of Mounting Ordnance. By Major Moncrieff, F.R.S.	The Author.
Lectures addressed to Officers of Volunteer Corps at the Royal United Service Institution, 1873	The Council of the Institution.
Report of the Final Examination held at the Staff College, December 1873	The Director-General of Education.
The Ferns of Southern India. By Major R. H. Beddome, Inspector of Forests, Madras	Col. W. C. F. Gosling, R.H.A.
The Ordnance Survey of the United Kingdom. By Captain H. S. Palmer......................	The Author.

Books, &c., purchased.

The Birds of Europe. Parts 17, 18, 19, 20, 21, 22, 23, 24, & 25. By H. E. Dresser, F.Z.S.
The Ibis. Nos. 10, 11, & 12. Vol. III.
Celestial Objects for Common Telescopes. By the Rev. T. W. Webb, M.A.
Manual of Gunnery for Her Majesty's Fleet, 1873.
The Conflict of Studies, and other Essays. By J. Todhunter.
On the Use of Field Artillery on Service. By Taubert. Translated from the German by Lieut. H. H. Maxwell, R.A.
Chemistry, Inorganic and Organic, with Experiments. By C. L. Bloxam.
Campaign of 1870–1. Official War Documents of the Head Quarters of the First Army. Translated by C. H. Von Wright.

Contributions to Solar Physics. By J. Norman Lockyer, F.R.S.
The Telegraphic Journal and Electrical Review.
Elementary Astronomy. By R. A. Proctor, B.A.
Ashantee and the Gold Coast. By Sir John Dalrymple Hay, Bt.
Journal of the Palæontographical Society, Vol. XXVII.
Queen's Regulations and Orders for the Army, 1873.
A Key to the Queen's Regulations, as revised in 1873. Malton.
Simmons, on Courts-Martial.
Army Estimates, 1874–5.
The Principles and Practice of Modern Artillery. By Lt.-Col. C. H. Owen, R.A., 2nd Edition.

Arundel Society Plates.

St. Anthony of Padua healing the foot of a young man.
St. Francis preaching before Pope Honorius III.

D.

Presentations to Museum.

Two Boxes of Proportional Military Models, containing a Battery of Royal Horse Artillery, and a Field Battery	Major W. A. Ross, late R.A.
One Indian Kingfisher	Lieut. W. L. Hutchinson, R.H.A.
17 Birds and a large Collection of Shells and Insects from Aden and India	Lieut. J. W. Yerbury, R.A.
42 Birds from British Burmah	Major J. W. Richardson, R.A.
One Pair of Markhur Horns, and one Head and Horns of Ravine Deer, India	Lieut. A. E. Turner, R.H.A.
Horned Tragopan, from India	Lt.-Col. C. M. Govan, R.A.
19 Birds from Jamaica...........................	Major J. R. King, R.A.
Two Black Guillemots, from Loch Broom, Sutherlandshire	The Rev. W. F. Short, M.A.
One Indian Monitor	Anonymous.
30 Birds from Southern India	Colonel R. Cadell, R.A.
A Cigarette Case, formerly belonging to the late Captain Brabazon, R.A., and a Head Dress belonging to the Chief Priest of the Temple of the Earth, just outside Pekin	Surg.-Major A. S. K. Prescott.
Mammalian Remains from the Pleistocene Deposits, collected in the neighbourhood of Woolwich by Captain H. W. Feilden, R.A. :— No. 1. Tusk of Elephas primigenius ...... " 2. Molar, E. primigenius .... " 3. Three portions of Femur of Elephas primigenius .... " 4. Scapular .... " 5. Skull and Horns, cores attached, of Bos primigenius..................	Captain H. W. Feilden, R.A.
Skull of a North American Coast Indian, from near Queen Charlotte Island	Major-Gen. W. D. Gosset, R.E.

Specimen of Silver Ore, from Pozo Rico Mines Guadul Canal, near Seville	Lt.-Col. A. W. Drayson, R.A.
Seven British Birds	Capt. W. H. King Harman, R.A.
A Silver-Mounted Matchlock, from the Armoury of the Rajah of Tanjore	Captain G. B. Macdonell, R.A.
Barbary Partridge	Captain W. H. Duthie, R.A.
Water Bottle (Regimental Pattern), worn by Bourbakie's Army in the war of 1871–2	Lieut. L. Tillotson, R.H.A.
Two Bottles of Burmese Reptiles	Major A. M. Rawlins, R.A.
Opercula of Great Queen Snail, from the Navigator Islands	Captain R. W. Sparks, 7th Royal Fusiliers, through Sec. R.A.I.

Bird from British Burmah, presented by Lieut. W. L. Hutchinson, R.A.

Pelargopsis brumanica.

Birds from India, presented by Lieut. J. W. Yerbury, R.A.

Poliornis teesa.
" "
Caprimulgus asiaticus.
Coracias indica.
Halcyon smyrnensis.
Merops viridis.
Orthotomus longicaudus.
Tchitrea paradisi.
Copsychus saularis.
Pyconotus hæmorrhous.
Alsenoax terricolor.
Acridotheres tristis.
Xantholæma hæmacephala.
Ægialitis philippinus.
Ardeola leucoptera.
Ibis falcinellus.

Rhynchæa bengalensis.

Also a Collection of Insects and Shells from Aden and India.

Birds from British Burmah, presented by Major J. B. Richardson, R.A.

Haliastur indus.
Poliornis teesa.
Circus melanoleucus.
" "
Strix indica.
Coracias affinis.
" "
Halcyon smyrnensis.
Alcedo bengalensis.
Merops viridis.
Pomatorhinus erythrogenys.
Trochalopteron variegatum.
Oriolus melanocephalus.
" "
" "
Parus monticolus.
Copsychus saularis.
Dicrurus macrocercus.
Myragra azurea. ♂
Rubigula gularis.
Arundinax olivaceus.
Pycnonotus pygæus. ♀
Siphia erythaca.
Lanius erythronotus.
Budytes viridis.
Arachnechthra asiatica. ♂ ♀ ♀
Dicæum coccineum.
Acridotheres fuscus.
" "
Temenuchus pagodarum.
Sturnopastor contra.
" "
Eulabes religiosa.
Passer flavicollis.
P. cinnamomeus.
Palæornis rosa.
Picus blandfordi.
P. macei.
Gecinus occipitalis.
Chalcophaps indicus.

Also a Collection of Insects.

Bird from India, presented by Lieut.-Colonel C. M. Govan, R.A.

Ceriornis satyra.

Birds from Jamaica, presented by Major J. R. King, R.A.

Aithurus polytmus. (Seven specimens).
Lampornis porphyurus.
Todus viridis.
Certhiola flaveola.
Ptilogonys armillatus.
" "
Merula leucogenys.
Quiscalus crassirostris.
" "
Tanagra zena.
" "
Centurus radiolatus.

Centurus radiolatus.

British Birds, presented by the Rev. W. F. Short, M.A.

Uria grylle (Black Guillemot).
" "

Birds from India, presented by Colonel R. Cadell, R.A.

Syrnium sinensis.
Coracias indica.
" "
Halcyon fuscus.
" "
Ceryle rudis.
" "
Merops philippinus.
Copsychus saluris.
Dicrurus macrocercus.
D. balicassius.
Pitta bengalensis.
Pastor roseus.
Muna undulata.
M. malacca.
Palæornis torquatus. ♂
P. bengalensis. ♂
Xantholœma asiatica.
Chrysocolaptes sultaneus. ♂
Centropus rufipennis. ♀
Coccystes melanoleucos.
Ithaginis spadiceus. ♀
Corturnix coromandelcica. ♂
" " ♀
Lobivanellus goensis.
Cinclus interpres.
Ardeola leucoptera.
Rhynchæ capensis.
Pelicanus philippensis.
" "

One Bird, presented by Captain W. H. Duthie, R.A.

Caccabis petrosa.

British Birds, presented by Captain W. H. King Harman, R.A.

Falco peregrinus ♀ (Peregrine Falcon).
Tinnunculus alaudarius ♂ (Kestrel).
Turdus viscivorus ♂ (Missel Thrush).
Hydrobata cinclus ♂ ♀ (Water Ouzel).
Corvus conix ♂ (Hooded Crow).
Vanellus cristatus ♂ (Lapwing).

Skulls and Horns from India, presented by Lieut. Turner, R.A.

Ravine Deer.
Markhur.

Presented by Brigadier-General Abbott, C.B.

Indian Monitor (young specimen, in spirits).

Presented by Major A. M. Rawlins, R.A.

Two Bottles—Reptiles in Spirits—British Burmah.

E.

Statement of Increase and Decrease of Members of the R.A. Institution during the year ending 31*st March*, 1874.

Rank.	31st March, 1873.	Additions.				Total additions.	Deductions.						Total deductions.	31st March, 1874.
		Promotion.	Retirement.	From retired list.	New members.		Promotion.	Retirement.	To effective list.	Resignation.	Withdrawal.	Death.		
EFFECTIVE LIST.														
General and Regimental Field Officers	425	24	—	—	3	27	—	11	—	—	—	5	16	436
Captains	269	41	—	—	7	48	24	4	—	4	3	1	36	281
Lieutenants	462	—	—	1	84	85	41	1	—	2	3	3	50	497
Paymasters	8	—	—	—	—	0	—	—	—	—	—	—	0	8
Quarter-Masters	6	—	—	—	—	0	—	1	—	—	—	—	1	5
Riding-Masters	6	—	—	—	—	0	—	—	—	—	1	—	1	5
Surgeons-Major	4	1	—	—	1	2	—	—	—	—	—	—	0	6
Surgeons	13	—	—	—	—	0	1	2	—	—	10	—	13	0
Veterinary Surgeons	4	—	—	—	—	0	—	—	—	—	1	—	1	3
RETIRED LIST.														
General and Regimental Field Officers	84	—	11	—	—	11	—	—	—	—	1	5	6	89
Captains	42	—	4	—	—	4	—	—	—	—	1	1	2	44
Lieutenants	11	—	1	—	—	1	—	—	1	—	—	—	1	11
Quarter-Master	0	—	1	—	—	1	—	—	—	—	—	—	0	1
Surgeons-Major	2	—	3	—	—	3	—	—	—	—	—	—	0	5
Surgeons	1	—	2	—	—	2	—	—	—	—	—	—	0	3
Veterinary Surgeons	1	—	—	—	—	0	—	—	—	—	—	—	0	1
Chaplain	1	—	—	—	—	0	—	—	—	—	—	—	0	1
HONORARY MEMBERS	46	—	—	1	2	3	—	—	—	—	2	2	4	45
Total	1385	66	22	2	97	187	66	19	1	6	22	17	131	1441

THE

CONSTITUTION AND DUTIES OF THE ARTILLERY

OF THE

ADVANCED GUARD OF AN ARMY IN THE FIELD,

BY

LIEUT. S. C. PRATT, R.A.

[THE R.A. INSTITUTION PRIZE ESSAY OF 1871.]

"*Multa petentibus desunt multa.*"

THE introduction of breech-loaders and rifled cannon has undoubtedly modified the whole system of modern tactics. The general principles regulating the dispositions of troops will always remain true, but their mode of application will vary according to the exigencies that altered conditions of warfare may give rise to. It is not easy to determine where the development and growth of new ideas should end. Certain changes in tactical forms result *naturally* from the introduction of new elements into warfare, provided that the value of those elements is accurately known and justly estimated. On the other hand, many debated points can only be settled by the establishment of new theories founded on a certain number of well known facts; care being taken as to the sufficiency of the evidence.

The tendency of the present day has been—in the case of advanced guards—to increase considerably their strength. This has arisen naturally from the increased range of modern weapons, and especially that of field guns. The main body of an army has to be protected from distant artillery fire while on the march, and while manœuvring to get into fighting order. To effect this, an advanced guard must be strong enough to hold a position without support at a sufficient distance from the main body—a condition only obtainable by the employment of a powerful force.

Before entering into details, it is necessary clearly to understand what an advanced guard is.

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An army always marches with as broad a front as is consistent with tactical requirements. This necessitates a division into several columns marching on separate roads. The object of the march, the nature of the country, and the number and direction of the roads, regulate the number of columns.

Each column may have its own advanced guard, or one may serve for the whole army. It has thus been laid down as usual to detail for the advanced guard one or more constituents of the main body.[1] Thus an army composed

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[1] "Art of War," Clausewitz.

of several army corps, would detach one for its advanced guard; if composed of divisions, one or more divisions would be sent. Where, however, a large compact body is sent forward as an advance to the whole army, it is not, strictly speaking, an advanced guard, as generally understood. It is simply a powerful detached body, which must expect to fight unsupported, and its mission does not obviate the necessity of having particular advanced guards to the head of each column. If, again, this detached body of troops is kept within fighting support of the main body, it will become tactically necessary to divide it into several columns, and it becomes virtually a series of advanced guards covering the heads of the columns of the army. It is, then, simply necessary to consider the ordinary case of an advanced guard covering the head of a column of an advancing army. It must be remembered, however, that as each column has its own advanced guard, that of the army consists of the sum of these several bodies—each being, as it were, linked to those adjoining it.

In the march of an army, again, it is often necessary to provide flanking detachments—sometimes improperly called advanced guards. The action of these bodies will not be considered, as their employment varies so much according to the circumstances of the case, and, not being on the true front of an army, they cannot properly be considered as advanced guards. On account of the space covered by a large number of troops, more than a corps is never marched on a single road, if it can be avoided, and marching by divisions is preferable. During the last war, the Germans always marched a division on each road when practicable.[1] The question, then, resolves itself into the consideration of the advanced guards of a corps and a division, as applicable in the generality of cases.

For convenience of reference, the composition and strength of the divisions and corps are supposed to be similar to those maintained in the army of the North German Confederation, the constitution of which is followed, more or less, by the great military powers.[2] The union of two or more army corps forms an army.[3]

Duties of Advanced Guards in general.

According to the best military writers, the *rôle* of an advanced guard is to facilitate the march and guard against surprise. The country through which

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[1] "More than a division was seldom placed on one road."—Pamphlet by Duke of Wurtemburg.

[2]

			Men.	Guns.
1st Division.	1st Brigade	Two regiments, each of three battalions	6350	
	2nd Brigade	Two regiments, each of three battalions	6362	
	One regiment cavalry		677	
	One division field artillery		634	24
	Total (adding Staff)		14,066	24
2nd Division			14,066	24
One battalion rifles			1056	
Corps artillery—six batteries and train			2601	36
Administrative services, pioneers, train, &c.			4482	
Total			36,421	84

An army corps will have thus about 31,000 fighting men.
A division " 14,000 "

[3] "Précis of Modern Tactics," Home.

the troops pass must be thoroughly explored, all obstacles to the march of the main body removed, and useful information of all kinds collected. The movements of an enemy have to be ceaselessly watched, and all small hostile bodies driven back. In addition, it has to manœuvre, contain the enemy, and give the main body time to prepare for action. In presence of an enemy, it is "not to advance or retreat, but manœuvre."[1]

An advanced guard has thus two opposite functions to perform—one, to be the eyes and feelers of an army; the other, to arrest and contain the enemy.

In order to perform the first, the troops should be of the lightest description, and chiefly cavalry. To attain the second, the main constituents should be a powerful infantry and artillery.

The endeavour to reconcile these conflicting functions is, without doubt, the reason of the great differences in the constitution of advanced guards as laid down by authorities on tactics.

The present tendency is to restrict them, more or less, to the latter duty; fulfilling the former by the employment of independent bodies of cavalry, one or more day's march ahead of the army.

In this case, the use of an advanced guard in protecting from surprise and collecting information of the enemy ceases, and it becomes practically the *first fighting line* of the army. It may not be possible, however, always to employ cavalry as a reconnoitring force, and the case of its non-employment must be provided against.

gth of nced ds.

Advanced guards are composed of the three arms, the relative strength of each being mainly dependent on the physical features of the seat of war. They are, in fact, miniature armies.

With regard to size, the official text books[2] of Russia, Austria, and Germany agree in assigning to them a proportion of from $\frac{1}{4}$ to $\frac{1}{3}$ of the main body. The French writers till lately were contented with a much smaller fraction, even reducing it as low as $\frac{1}{20}$ in some cases.[3] Their most recent publications, however, maintain the correctness of the German standard.[4] Belgian writers fix $\frac{1}{5}$ as a proper normal proportion.[5] Wolseley, apparently following Dufour, approves of from $\frac{1}{5}$ to $\frac{1}{10}$ of the whole force.[6]

It may be assumed, then, that an advanced guard should vary in strength from $\frac{1}{4}$ to $\frac{1}{6}$ of the army, as a general rule. This large proportion need not be strictly adhered to in the case of small bodies of troops, and where the country presents exceptional features. Within these limits, the strength is generally increased as the columns become deeper.

nce Main .

The distance from the main body varies much, according to circumstances; a rough rule being that the interval between the head of the column and the main body of the advanced guard should be equal to the depth of the column. This distance should, however, rarely exceed five miles; the sole exception being the case of "desiring to seize some point or position the possession of which would be worth the risk"[7] of incurring a defeat while

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[1] Napoleon.
[2] Regulations for Field Service of Prussia. Do. of Austria. "Armed Strength of Russia."
[3] "Cours d'Art Militaire," Vial.
[4] "Conférences du Ministre de la Guerre."
[5] "La Tactique Appliquée au Terrain," Vandevelde.
[6] "Soldier's Pocket Book."
[7] "Operations of War," Hamley.

beyond reach of support.[1] The special employment of any one arm in the advanced guard cannot be considered without constant reference to the other branches of the service with which it is allied. The normal action of the force is, besides, a case where the mutual dependence of the three arms is especially prominent. The constitution and duties of the artillery can best be judged of by considering the advanced guards of

Firstly. An army on the march.
Secondly. An army in immediate presence of an enemy.

First Case.—An Army on the March.

Relative Position of several Arms.

All tactical writers agree upon the necessity of having a normal order of march.[2] Though circumstances and features of the soil vary incessantly, it is necessary to have a fixed method in progression. Experience teaches us that in nine cases out of ten that may arise, a normal order of march need not be interfered with. The few exceptional instances are well known, and their modifying influence clearly defined. The troops leading the advanced guard regulate the rate of advance of the main body. As, in addition to progression to the front, they have sundry duties of reconnoitring and clearing away obstacles of all kinds, it is evident they should be very mobile. Cavalry, then, when the ground admits of it, takes the head of the column. As cavalry has to fall back in presence of small bodies of hostile infantry, and cannot enter defiles of any kind alone, it has to be supported by a certain force of infantry. The main body of the infantry, whose duty is to arrest the enemy by either offensive or defensive action, will naturally be further in rear. The artillery must be sufficiently far forward to meet the first shock of the enemy;[3] at the same time, its main object is to assist and support the action of the main body of the infantry.

As a result of these considerations, an advanced guard is divided into a main body, consisting of the major portion of the infantry and artillery, and an advanced body, or vanguard, composed of the lightest troops. In the case of a large advanced guard—such as that of a *corps d'armée*—an intermediate body is generally necessary to support effectually the van.[4] Communication has to be kept up between these several constituents, and also with the main column and neighbouring troops—a work usually effected by cavalry. Patrols and skirmishers have to be sent out to search the country, and small bodies have often to be detached to cover unprotected flanks. Artillery is rarely sent with these detachments. It is impossible to lay down exact intervals between the various portions of an advanced guard, as the state of the weather, the features of the country, and the number and constitution of the troops, are all disturbing causes. The great principle to be

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1 "In the advance of the 3rd, 7th, and 8th German Corps towards Saarbruck, the advanced guards were from 3 to $4\frac{1}{2}$ miles ahead."—"Attack of Prussian Infantry," by Duke of Wurtemburg. Passing through the Trautenau defile, in 1866, the advanced guard of the 2nd Division was $1\frac{1}{2}$ miles ahead of the main body.

2 "Il faut avoir des principes; il ne faut pas se livrer au hasard de l'inspiration."—Bugeaud.

3 "Ausbildung der Infanterie," Von Waldersée.

4 The larger advanced guards are divided into a front troop (*vortrupp*), main troop (*haupttrupp*), and main body (*gros*).—"The Army of the North German Confederation."

recognised is, that the *gros* or main body of the guard should not be exposed to distant artillery fire until it is formed up in fighting order.[1]

With regard to the proportion of artillery allotted to the advanced guard, the modern tendency to increase it cannot escape notice.

In the series of advanced guard engagements in 1866, the want of guns was generally severely felt. One of the principal features of the artillery tactics in 1870 was the "engaging in force in advanced guard actions;"[2] and the tendency of the latest writers is to exceed the proportion actually employed in that campaign. The difference between modern and ancient practice on this point is most striking. Under the 1st Empire the advanced guard of a corps had often but two guns, while now each division detaches at least a battery to its front, and a corps employs two, three, and occasionally four batteries. Guns formerly employed merely to give notice of an enemy's approach, are now recognised as a necessary adjunct to a severe combat.[3]

It may be assumed that on the march a division attaches one battery to its advanced guard (occasionally two), a corps two, and often three.[4] In the case of an army advancing by roads close to one another, the advanced guards of each column can afford one another mutual support to some extent. In such a case, the proportion of guns heading each column need not obviously be as great as when there is no prospect of such support.

As to the position on the march of the guns, there are slight differences of opinion. The necessity of having them at any moment to the front, forbids that they should march in rear. The liability of roads and passages to be blocked by on-pressing troops, is apparent to all. The general opinion, founded on the experience of the last two wars, is that the majority of the guns should be placed at the head of the main body of the advanced guard, covered by a small force of infantry—usually a battalion.[5] In the case of a large advanced guard, such as possessed by a corps, it is advisable to detach one of its lightest batteries to march near the rear of the vanguard. Thus a division will have its one or two batteries marching close to the head of the main body; a corps will have the majority of its guns similarly placed, but attaches one to the van.[6]

In apportioning the artillery to the advanced guard, tactical units must be

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[1] Rear of vanguard to head of main body of advanced guard of a division, 500 to 600 yds., according to Verdy du Vernois; 600 to 700 yds., according to Home. Where country is very open, cavalry being solely used in van, 2500 yds.—"Armed Strength of Russia."

[2] "Tactical Deductions," Boguslawski.

[3] It will be interesting to contrast the ideas of Marshal Ney, as delivered to his officers at the camp of Montreuil, in 1804, with those of the present day. Giving instructions for the advanced guard, he said:—"It shall open its march with a squadron of cavalry, a company of carabineers, a gun, a battalion, behind which shall be a gun or howitzer. The rest of the infantry shall follow with the artillery. The piece of cannon at the head of the column shall be fired as rapidly as possible the moment the enemy is found in force, in order to give notice to the army."

[4] Hohenlohe, looking at it in an artillery point of view, lays down three or four batteries as requisite for a corps.

[5] "Là elles seront egalement bien placées pour agir offensivement, pour favoriser le déploiement des colonnes où pour tenir l'ennemi à distance en cas de retraite."—"La Tactique appliquée au terrain," Vaudevelde.

[6] "Employment of Field Artillery," Hohenlohe. "L'emploi du Canon de Bataile," Taubert. "Gebrauch der Artillerie im Feld," Général-Major Bylandt-Rheidt. "Studies in Troop Leading," Verdy du Vernois. Von Waldersée. Le Bourg.

kept together as much as possible. The battery is the smallest artillery unit, and its subdivision is always to be deprecated.[1]

Constitution of Batteries.

The nature of the batteries of the guard has been considerably discussed. Should they be composed of heavy or light artillery, or a mixture of the two?[2] The advanced guard artillery has often to seize with rapidity a favourable and often exposed position. To move rapidly, mobility is specially requisite; to maintain successfully an exposed position, the most effective gun against troops is advantageous. Firing against troops, the effect is proportional, to a great extent, to the number of projectiles fired. The lighter gun can carry and expend the greatest number of shell, and it is therefore a mistake to employ a heavier calibre than is *sufficiently effective*. In the attack of villages, earthworks, and obstacles of any kind, the heavier gun has, of course, the advantage. "In any case, the artillery of the advanced guard has to come into action first, and has to remain there the longest;"[3] the light battery is therefore generally preferable, as possessing the most ammunition. The disadvantages entailed by the employment of two calibres of field guns outweigh the advantages. Neglecting the purely artillery details, it will be difficult generally to foresee the cases where each gun will be employed to the best advantage. The possession of one calibre at any period when the other would be preferable, has a decidedly bad moral effect on troops, who ought to feel a thorough confidence in their own artillery.[4] It is advisable, then, to use light field batteries, as a rule, for the advanced guard, employing heavy ones, when available, only under exceptional circumstances. Take, for instance, the case of the 4th Bavarian Division the day[5] the Crown Prince's army crossed the frontier, in the last war. Its orders were to endeavour to gain possession of the semi-fortified town of Weissemburg. A heavy battery was, in consequence, very properly sent with its advanced guard, while two days later in its advance on Froeschwiller a light battery was substituted.

It will happen sometimes that an advanced guard is strong in cavalry. In this case, it is advisable to have one horse artillery battery attached to it.[6]

Experience of the last War.

It will be interesting to study one or two instances of the march of advanced guards in the last war, noticing the force and position of the artillery. Take as an example the march of the 5th German Army Corps across the French frontier, on the 4th August, 1870.[7] This corps was marching by a single road towards the river Lauter, which separates France from the Rhenish Palatinate. The duty entrusted to the advanced guard was to precede the corps to within about a mile of the frontier, then to divide into

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[1] "Il faut éviter de former des détachements d'artillerie en sections ou demi-batteries ce serait là, en thèse générale, méconnaitre les propriétés tactiques de cette arme."—Taubert.

[2] Represented in our service by the 16-pr. and 9-pr. M.L. rifled guns.

[3] "Studies in Troop Leading," Verdy du Vernois.

[4] The Prussians are well aware of the disadvantages of two calibres. In their new equipment, now in course of construction, there are only two calibres recognised—one of 8·8 centimetres for field guns, and one of 7·85 centimetres for horse artillery. For an able argument in favor of unity of calibre, see the "Revue Militaire Suisse" of January, 1874.

[5] 4th August, 1870.

[6] During the last war, there was constantly a difficulty in getting the German heavy field batteries to the front. If it is considered that these guns are only ½ cwt. heavier in draught than our 9-pr., it is evident that any argument against having heavy calibres in the advanced guard applies with additional force when the weight of the 16-pr. M.L. is in question.

[7] Official account.

two columns, cross the Lauter, take up a position on the opposite bank, and establish connection with the advance of the two neighbouring columns. Two light batteries were attached to the guard. While marching on the single road, one battery was attached to the vanguard, and marched near the rear of the van, preceded by two squadrons and six companies, and followed by a battalion. The remaining battery marched at the head of the *gros* of the advanced guard, covered by a fusilier battalion. On reaching the neighbourhood of the Lauter, a division into two columns was made, one battery being attached to each. As a general rule throughout the war, the Germans attached two batteries to the advanced guard of an army corps while on the march, but reinforced them generally, when possible, previous to an engagement. Thus the 11th German Army Corps brought four advanced guard batteries into action on the morning of the battle of Woerth.

An example of another kind is the march of the 4th Bavarian Division towards Froeschwiller, on the 6th August, 1870. One light battery was attached to the advanced guard, and marched at the head of the main body of it, covered by a battalion of infantry.

The advanced guard of the 13th Division (First German Army) crossed the frontier in similar order the same day, with one light battery. On hearing firing in the neighbourhood of Forbach, to which they were approaching, an additional battery was added.

Hitherto, the position and proportion of the artillery force under ordinary circumstances has been considered. Exceptional cases must also be noted—such as a march through a defile, or in an unusually difficult country.

There are many varieties of defiles, but the only ones actually influencing the march of troops are mountain passes or forest roads. The consideration of the former embraces all the requisite points.

When a defile is very long, an enemy may occupy a position in the interior of it. In the generality of such cases, the defile would be forced by outflanking movements of infantry, and the head of the advanced guard would consist mainly of that arm. The main body of the artillery would be kept back, behind the *gros* of the advanced guard, sending forward guns when necessary to overcome obstacles in the road. In all questions of this sort it must be remembered that no absolute rule can be laid down, the features of the soil of themselves causing variations that cannot be calculated upon.

In the most ordinary case of a defile, when an enemy defends the *debouché*, the following principles are recognised. The artillery must be powerful and well in front, to prepare the assault on the enemy's defensive position. The intervals between the several bodies of troops, while passing the defile, must be lengthened. At the same time, "all that can possibly be done to diminish the length of the column till the defile is forced, should be attended to."[1]

All experience shows—notably in the campaign of 1866—the importance of getting guns speedily to the front. Owing to the usually difficult nature of the ground, however, it may not be easy to find positions for them at first. There will always be an opportunity for placing two guns either on the road leading through the defile, or at its sides. With these guns the attack may be "vigorous, and the initiative kept."[2] Considering, then, the advanced guard of a corps, two guns would be detached to the

[1] "Wellington Essay," Maurice.
[2] Von Waldersée.

front, with a few cavalry and infantry; the rest of the battery following, at a considerable interval, with an infantry battalion.[1] This battalion would act as a support to the advance, and the interval in front of it gives space for choosing positions for the four guns. At a further interval, the next battalion and battery which follow in their turn precede at some distance the main body of the advanced guard with the remainder of the guns. The bulk of the wagons of the artillery would follow in rear of this main body.[2]

The preservation of considerable intervals between each portion of the advancing troops is necessary. The line of march may at any time be subject to distant artillery fire, and the columns in front are liable to be checked and cause confusion among troops following too closely.

Modifications in the order of march have to be made when the country to be traversed presents exceptionally difficult features. A marshy intersected plain—like parts of Italy—a densely wooded tract, or very rocky and broken ground, have sometimes to be marched through. In all these cases the roads become a series of defiles, and many of the foregoing considerations apply in consequence. It will be generally found, however, that these obstacles impede equally the defence of an enemy, and restrict his action, more or less, to the roads. The route will have to be cleared mainly by infantry, whose power is the least trammelled in these cases. The action of the artillery would be much limited, and the disadvantages of blocking the roads with guns is apparent. The guns, then, will generally march in rear of the main body of the advanced guard, detaching a couple to the front if found necessary.

2nd Case.—An Army in Presence of an Enemy.

When an advanced guard comes in contact with an enemy in force, its patrols and skirmishers have to fall back on their supports, which either hold their ground or retire, according to circumstances. The main body of the advanced guard will have to deploy more or less of its troops, and prepare itself either for an offensive or defensive action. General Considerations.

In theorising on advanced guard actions, care must be taken to denounce the very common error of a mere concentration on the advance by the main body. This was specially noticeable in the campaign of 1866, where the advanced guards "became usually hotly engaged, frequently got into difficulty, and could only be supported by successive reinforcements from the main body."[3] During the last war, the tactical management of this force was much better, though Spicheren is a notable instance to the contrary.

A most striking instance of the judicious employment of advanced guards is afforded by the commencement of the unpremeditated battle of Colombey, on the 14th August.[4] The French were retiring slowly from a strong

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1 "To detach guns, however, in this way, is only exceptional; the rule being to keep them together."—Verdy du Vernois.

2 As a general rule, the wagons are with the guns. "Aux avant-gardes, l'artillerie doit tenir toutes ses voitures bien réunies.—" Essai sur l'Organisation de l'Artillerie," Le Bourg.

3 "Tactical Deductions," Boguslawski.

4 "Operations of 1st Army," Von Schell.

position near Ars Laquenay. The advanced guard of the 7th German Corps attacked them vigorously, using two light batteries to cannonade the buildings near Colombey, and drove the defenders out. The French then made a partial deployment, and assaulted the troops of the advanced guard with very superior forces. In spite of the strong attack, the troops of General Golz held their ground for 2½ hours, till the arrival of the main German forces made the action general.

As another instance, the action of the advanced guard of the 24th Saxon Division at Sedan may be noticed. Capturing the village of La Moncelle, the infantry pushed across the Givonne rivulet, taking possession of detached houses on the west bank, forming a sort of tête de pont position, which was maintained for three hours under the most trying circumstances. At the same time, the light battery of the advanced guard deployed on the eastern side of the Givonne valley, and opened fire on the long lines of the enemy visible on the western heights. This single battery maintained its position unaided against a very superior force, till reinforced by the divisional artillery.[1]

It is always advisable, if possible, to bring three batteries into action, on account of the mutual support they offer each other. The commencement of the battle of Woerth illustrates the value of this combined action. Two advanced guard batteries of the 21st (German) Division were opposed in front and flank by five French batteries, and were in danger of giving way. By the co-operation, however, of the nearest battery of the 5th Corps they were enabled to hold their ground, and, in consequence, took subsequently an important part in the fight.[2]

When a plan of action is decided upon, the intelligent co-operation of the artillery depends chiefly on the abilities of its commander. If the guns are to be used to the greatest advantage, they must be worked in intimate relation with the requirements of the other arms. The senior officer of the artillery should therefore be with the commander of the advanced guard during the movements prior to the action, and constantly refer to him while the combat is going on.

It is advisable to employ artillery in divisions when practicable, on account of the facility of transmitting orders.[3] In the case of a single battery, the Major would be with the Commandant, and the battery practically be under command of a Subaltern, often at the most critical moment.[4] A field battery, besides, cannot well spare more than one trumpeter to act as an orderly. If a division is employed, the Lieut.-Colonel would be with the Commandant, have sufficient orderlies, and the efficiency of the individual batteries would not be diminished. It is, of course, impossible to avoid the employment of single batteries in advanced guards, but the evil is none the less apparent.

This facility of transmission of orders is also embraced in the vexed question of whether batteries should be employed massed or dispersed, for both of which there are able advocates.[5]

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[1] "Franco-German War," Borbstaedt.

[2] Official account.

[3] In our service, usually from two to three batteries.

[4] The Captain being with third line of wagons.

[5] "The old dispute between massing guns or concentrating the fire of separated batteries, is held by all who have seen war on a modern scale as unpractical. So many guns are brought into action

Take the ordinary case of two or three advanced guard batteries ordered to concentrate their fire on some special point. It will often happen that this is not visible from the different positions the batteries, if dispersed, would take up. It is evident that both time and ammunition are saved by batteries being placed near enough to communicate freely, as to range, &c., with each other. In addition to ease of transmission of orders, it must be remembered that the advanced guard artillery expects to be strongly reinforced by the guns of the main body of the army. If the batteries are not kept well together, the probable mixture of different commands, resulting from the advance of the divisional artillery, could only lead to confusion. Whatever, then, may be the advantages of dispersion of batteries—and no doubt they are occasionally great—the last-named reason is sufficient to condemn the application of that principle to advanced guards. Occasionally—particularly in a defensive action—circumstances admit of a battery taking an enemy in flank. This will seldom be advisable with a force of less than three batteries, but when employed the effect is very great, and warrants the detachment of a battery.[1] This seems a case where horse artillery could be used to advantage, if at hand.

The principle of massing guns applies most strongly against the subdivision of a battery. There are exceptional cases, however, when it is necessary—such as the passage of defiles, destruction of obstacles, small reconnaissances, &c. In such cases, guns should be detached by divisions, and not half-batteries.[2]

At the commencement of an engagement, it is often difficult to determine the amount of resistance the enemy is prepared to offer. The forms which the combat may assume vary accordingly, but they may be divided into two general phases.

Firstly. The offensive combat.
Secondly. The defensive combat.

The Offensive Combat.

If the enemy has drawn up his troops, and is apparently under the intention of adopting the defensive, the artillery of the advanced guard has to commence the action and prepare the way for the attack.

The fight should rarely be commenced at a distance of more than 3000 paces.[3] Artillery has a natural tendency to open fire at too long ranges—a failing especially prominent in the campaign of 1866.

The Elbe army at Sedowa did nothing but exchange shots with the enemy at 4000 or 5000 paces.[4] In the defile actions of the Crown Prince's army, in the same campaign, a similar tendency was apparent, and in all of them the want of effective artillery action was felt. The fear of losing guns,

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at once, that the only difficulty is how to find positions for them."—Lecture at U.S.I. by Major Brackenbury, R.A.; R.A.I. paper by Major Strangways; Hohenlohe. "It is found best to concentrate batteries in masses, near enough to each other to be subject to single direct control, and to give each other the benefit of any experience gained as to range and effect."—"Operations of War," Hamley.

[1] "Ce moyen est plus efficace que celui qui se bornerait à renforcer le front de la position."—Von Waldersée.

[2] "Minor Tactics of Field Artillery," Captain Hime, R.A.

[3] Hohenlohe, to whom constant reference is hereafter made.

[4] "Tactical Retrospect," May.

and the consequent traditional disgrace, undoubtedly gave rise to this practice—a gun being looked on in the light of a regimental colour.[1]

It is now recognised that, to combine effectually with the other arms, artillery will often have to advance to comparatively close ranges. To obtain a tactical success, guns must sometimes be sacrificed—the preservation of the unit being subordinate to the success of the army.

The artillery fire should at first be rapid or slow, according to circumstances. If the enemy is not strong in troops or position, the fire should be rapid, the attack made brusquely, without delay or too much method—attempting, as it were, to impose upon and surprise the hostile force.[2] If, on the contrary, it is evident that serious resistance has to be encountered, the guns should fire slowly and with great care.[3] The advanced guard batteries are constantly liable to be engaged, and when seriously so, remain in action longer than the artillery of the main body. As a consequence, their ammunition should be husbanded as much as possible, as there is often difficulty in replacing it. Although sparing of stores, the guns should fire without intermission. The general object to be gained is to make the enemy display his strength, at the same time exposing one's own as little as possible. The less forces are deployed, the greater the success.

What the artillery should fire upon, has always been a mooted point. It has been said[4] that in each phase of a fight some one arm of the enemy is the most effective, and on that arm the artillery fire should be directed—a good rule, doubtless, but somewhat difficult of application. The maxim of Hohenlohe is simpler; *i.e.*, only to fire at the enemy's artillery when there are no other troops to fire at—a principle which may be considered as true in the main.[5]

At the commencement of the engagement, the guns fire generally on the enemy's artillery—more for the purpose of drawing his fire, and making him display his forces, than for the actual damage likely to be inflicted on him.

During this slow cannonade, the plan of attack is resolved upon. The batteries will have then to advance, and direct their fire on the other troops, as soon as they are visible, firing at the hostile artillery when they are not.

Above 1000 paces,[6] the artillery plays the principal part; at lesser distances, it becomes of secondary importance.

The value of the artillery fire consists in its power of shaking the enemy and throwing him into disorder. "To turn this disorder to account, is the province of the other arms."[7]

Decisive results of artillery against artillery can only be reckoned on under 2000 paces. Above 2500, the effect is merely nominal; but against the other arms, an efficient fire can be kept up from as far as 3000 paces.[8]

The advance of the artillery to their nearer position preludes the second

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[1] The Germans "have got rid of the prejudice that the loss of guns must be avoided at any price."—Boguslawski.

[2] "La Tactique Appliquée au Terrain," Vaudevelde.

[3] "Essai sur l'Organisation de l'Artillerie," Le Bourg.

[4] "Use of Field Artillery," Taubert.

[5] *Vide* Sir John Burgoyne's "Opinions," and the formidable list of authorities quoted by Captain Hime in his essay.

[6] The German *schritt* of 29·65 ins.

[7] "About Tactics," Laymann.

[8] Hohenlohe.

phase of the attack. This position will probably be gained with little loss by a rapid advance in open order; small moving objects, such as guns, presenting a difficult mark to distant fire.

The position to be taken up must be previously well reconnoitred, and judged of with reference to the requirements of the artillery force and proposed combined attack.

In preparing the attack from this position, great importance is laid on the concentration of fire. Massing guns gives great facilities for doing so. When firing against artillery or mitrailleuses, it is advisable to direct the fire of several guns against one till it is silenced, then concentrate fire on the next one, and so on.[1] In the case most likely to arise, of firing against infantry on the defensive, it must be remembered that they have selected favourable ground, are not so limited to position as artillery, and that in consequence the efficacy of the artillery fire will depend more on the moral effect produced than on the actual number of troops put *hors-de-combat*. When, then, infantry are making a stand, a rapid concentrated shell fire is the most effectual; and as the assault advances, the fire should be intensified. To give proper effect to this fire, the guns may have further to advance, taking care to keep out of effective infantry range.[2]

When the hostile position is considered sufficiently cannonaded, the infantry attack takes place. As the infantry advances, the guns will become gradually masked. They should continue firing over the heads of the troops as long as they can with safety. When this is impossible, the fire should be directed on any of the enemy's guns that are effective, or upon reserves in sight, according to circumstances. If the position is carried, the guns will have at once to advance and occupy it, both for the purpose of defence against re-capture, and to fire at the retreating enemy. This is a special instance when the guns may continue to fire at very long ranges. The serious effect of losses produced thus on a retreating enemy, and the influence on the *morale* of the troops, has been amply exemplified in the last war.[3] If the attack is unsuccessful, the guns will have to check the advance of the enemy and cover the retreat of the troops. Where the adoption of the defensive is thus forced upon it, the artillery must be prepared to hold its ground as long as possible, and not think of its own safety too much. If, during the attack, the enemy is found too strong to be encountered by the advanced guard alone, the batteries of the division are hurried to the front. The massed artillery have then to extricate their infantry, if seriously engaged, or carry on a delaying action till the main body of the division is ready to take part in the engagement.

At the commencement of an action, the guns will, as a rule, be on the flank of the attacking troops. To gain its first decisive position the artillery

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[1] In the last war, a concentrated artillery fire generally rendered useless the French mitrailleuse batteries.

[2] 600 to 700 yds.—"Précis of Modern Tactics," Home. Major Home, however, advocates artillery never coming within 1000 yds. The German guns, in 1870, were generally pushed much closer; with heavy loss, but great effect. Captain Hime gives 900 yds. as the limit to the dangerous zone of infantry fire.

[3] "Ceux qui ont pratiqué cette règle dans la dernière campagne ont fait eprouver à leurs adversaires des pertes d'autant plus serieuses qu'elles ont toujours produit un effet moral désastreux."—Hoeller, "Tactique Contemporaine."

will often have to advance rapidly to reach some favourable spot.[1] To attain this with safety, there is a necessity for a temporary escort (usually cavalry). As the attack progresses, one flank of the guns will be protected by the advance, the other flank generally remaining in want of support till the main body of the army comes up and envelopes both flanks. The question of suitable support for the artillery is a difficult one, and will be treated further on.

The main principles which regulate the tactics of the advanced guards of a corps and a division are similar. In the former case, however—where the force is a larger one—it is evident that the vanguard (supplied with artillery), will come into action first. This will be supported by the main body of the advanced guard, and eventually by the corps. But with the corps, a new force comes into play—the reserve or corps artillery. These guns are directly under the command of the commander of the corps. To them is entrusted the work of screening the advance of the main body, and by coming into action with the advanced guard, concealing the intended main attack.[2] The divisional artillery can seldom separate itself from the main body, and confines its efforts to the local objects of the fight. When the main attack is directed towards a part of the field where the advanced guard is not engaged, it is prepared by the corps artillery, assisted generally by the divisional; but the advanced guard batteries confine their efforts to their original object.

e Defen-
e Combat.

"Defensive fights are, as a rule, with regard to their design and to the employment of artillery, far easier than offensive ones; although in the practical carrying out they are infinitely more difficult."[3] When an advanced guard assumes the defensive, it is prepared to be attacked by considerably superior numbers. The moral effect of a retreat is so bad, that every effort must be made to stand firm and not give way—a task rendered easier by the certainty of eventual support from the advancing main body. When the attacking force is *very* superior, the distance between the advanced guard and main body should be diminished, to facilitate support. With a properly organised force, the advanced guard should *never give way*. Without entering into the vexed question of how far the attack and defence have severally benefited by the introduction of the modern arms of precision,[4] it may be taken for granted that the "temporary retaining power of a relatively small number of men has largely increased."[5]

This is more notably the case where reinforcements are expected—as in the case of advanced guards. The greatest danger a small body of troops is subjected to, is the liability of being turned on the flanks. This would

[1] A distance of from 500 to 1000 paces.—Taubert, Hohenlohe. Hamley assigns 800 yds.

[2] "La plus grande faute que l'on puisse commettre est de conserver à l'artillerie, même à celle du corps d'armée, le rôle d'une réserve."—Becker, "Field Artillery in 1870–1."

[3] Hohenlohe.

[4] In most of the arguments on this subject, the tendency has been to discuss the general question of attack and defence, where the new arms are employed, and not separate the distinct influence modern weapons have on the relations that have always existed between them (*vide* Moltke's pamphlet). In 1870, roughly speaking, the French losses were half the German when on the defensive, and in the proportion of ten to three on assuming the offensive. Does not this exceed considerably the relative proportions of former days? The attack, again, has undoubtedly gained in the ability to advance supported by the fire of stationary troops.

[5] "Wellington Essay."

generally be guarded against, in the special case considered, by the advance of the main body. On the other hand, some of the usual advantages of the defence will probably be lost. Combat will often have to be accepted in an unfavourable position, and opportunity be seldom given for throwing up temporary entrenchments. The weak point of the position will usually be its flanks. The support of troops from the main body cannot always be depended on, and additional measures for security must be taken. It is generally difficult for a comparatively small force to find obstacles on which to rest its flanks, and it must be remembered that "a small body of troops should never extend its front inordinately for the purpose of securing its flanks."[1] For this reason, and in order to obtain the advantage of a cross fire, the guns are placed in position on one or both flanks.

The preliminary dispositions for a defensive fight are easily settled; the after arrangements depend on the progress of the attack. The practical difficulty of the defence is, that—in addition to the depressing influence of remaining passive, and other disadvantages—no mistakes should be made. The mistakes of an assailant can easily be remedied, but every error in the defence is at once taken advantage of by an able opponent. The guns, then, are placed on the flank or flanks, and arranged so as to search thoroughly the ground over which the enemy must advance. When guns of different calibres are employed, the heavier ones—having longer range and inferior mobility—are put further to the rear than the rest, being placed in re-entering angles of the artillery position, when they exist.

The assailant will, as usual, commence the attack with artillery fire, and it has to be considered what steps should be taken by the defender's batteries.

It has been said that "to silence the attacking guns is the essential object of the artillery on the defensive;"[2] and it is without doubt true, within certain limits. As the attacking guns have to prepare the way for their infantry, the fire of the defender will first be directed against them.

On the infantry, however, the burden of the attack rests; and as soon as it is within effective range, the guns must be turned on it. When to leave off firing at the artillery and turn the guns on the infantry, is a question that the genius of the commander, influenced by the special circumstances of the case, must decide. The main object of the defender is to compel an early deployment of the hostile force. Under conditions *favourable* to defence, the attacking force comes within effective artillery fire at a distance of 3000 paces,[3] and has to commence its deployment into small units.[4] As the attack proceeds, skirmishers advance, followed by supports and the main body.

The artillery of the defence has a great advantage in being acquainted with the ground, and the distances of various points in front of its position. It should, in consequence, commence firing before the enemy does, and by a well-judged accurate fire keep the hostile guns at as great a distance as possible.

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1 "Influence of Modern Arms of Precision," Moltke.

2 "Tactical Retrospect."

3 "New Tactics of Infantry," Scherf.

4 After the attack on Le Bourget, it was strictly forbidden to lead troops in close order within a nearer distance than 2000 paces.—Duke of Wurtemburg. *Vide* scheme of attack in "Précis of Modern Tactics."

After a time, the fire will be directed on the advancing infantry; but the movements of the enemy's artillery should be carefully watched, as opportune moments occur occasionally when a round or two of shell at it is very effective—such, for instance, as a movement to a flank, or a delay in unlimbering.

When an advanced guard is powerful in artillery, the deployment of the enemy's infantry at a distance can probably best be forced by the temporary advance of a battery to the front, supported by cavalry.[1] The lightest battery would, of course, be sent.

As mentioned before, in the case of the offensive, the detachment of a light battery with a strong escort, to take the enemy's guns in flank, is very effective, if possible.

As the infantry attack proceeds, the fire of the defender's artillery is intensified, the effect of the hostile artillery being kept down, in the main, by skirmishers.

The question then arises of whether to fire on the enemy's skirmishers, or on the main body and supports. The circumstances of the case decide this, of course, to some extent. It must be remembered that the conditions of warfare are somewhat modified—the skirmishers of ten years back did not play the same part as those of to-day. Now they represent the *first fighting line*, and in consequence must receive a large portion of the defender's fire.[2] To what extent they do so, depends mainly on the way in which the attack is conducted, the features of the ground, and the scheme of defence.

It may be taken for granted that the moral effect of the artillery fire far exceeds the actual, and on this account the fire against troops in open order has a greater influence on a fight than pure theory would usually give.[3]

The necessity of an advanced guard holding its ground has already been dwelt upon. The artillery will have to hold out to the last, combining, in the final stage of the attack, the fire of case with that of their own infantry.

When a retreat is necessary, the advanced guard of a column becomes the rear guard, and must protect the retiring troops as well as it can. The guns will have to check the pursuing enemy, taking ground to the rear by successive portions—in fact, retiring in échelon, as far as the ground will permit.

In ordinary cases of defence, a portion of the artillery would be held in reserve. This is, however, rarely advisable in the case of advanced guards, but care should be taken not to expose unnecessarily the true strength of the batteries at the first stages of the fight.

Under the conditions in which advanced guard combats usually take place, a defensive fight may often change into an offensive one, and *vice versâ*. The general rules above laid down will, then, be applicable to the special phases to which they belong.

...iles. It is necessary to notice the case of defiles, and exceptionally difficult country. As to the latter, no rule can be laid down, as the *rôle* played by the guns will be generally slight, and totally dependent on the features of the ground. Where an enemy occupies the *debouché* of a defile, the artillery of

[1] Scherf.

[2] Pamphlet on Attack, by Colonel Fielding.

[3] At Gravelotte, when taking the offensive, 94 per cent. of the German killed and wounded were due to musquetry fire, and but 5 per cent. to artillery fire.

the advanced guard plays a very important part. On it depends, to a great extent, the success of the engagement. As noticed before, it is advisable to get as many guns as possible to the front; but, on the other hand, there is generally great difficulty in finding positions for them. The attack will be often very difficult, guns will have to be sacrificed, exposed positions taken up, and the welfare of individual batteries subordinated to the success of the army. Guns will have to be placed wherever they can find positions. A couple of them may come into action by the side of the road, at the commencement of the fight; but the majority should try to get away to the flanks, ascend commanding positions, so as to be able to fire effectively over the head of the attacking troops, and endeavour to take in flank the enemy's position.[1] At Nachod, in 1866, two advanced guard batteries enabled a battalion to resist the attack of an Austrian brigade for three hours, till reinforcements arrived. The action of the artillery in 1866 was, however, defective; and we have no experience of a successfully forced defile under modern conditions.[2]

Connected intimately with the artillery question, are the considerations relative to escorts. Their necessity is recognised by all, but how practically to obtain them is a matter much discussed. There is no doubt that the artillery of the advanced guard is exceptionally exposed,[3] and in order to play its part boldly, must either risk loss and capture or be provided with efficient support. Some writers—like Captain May—have advocated *special* escorts;[4] but the majority have assumed that the development of the fighting line will afford sufficient support, and where it does not, a temporary detachment can be sent for the purpose. To detach permanently an efficient escort to each battery, would weaken too much the fighting strength of an army; to give too weak a one, is plainly a waste of troops.[5] The difficulty was not met in the last war, and in consequence the guns were frequently much exposed—notably in the case of great battery to the north of Floing, on the day of Sedan. Viewing the duties of the advanced guard as previously sketched, the matter becomes still more intricate. Where batteries have to advance rapidly to the front to gain a good position, it is evidently necessary for them to have a mounted escort; when they have gained their position, infantry support is required. Advanced batteries, then, require a double escort, both infantry and cavalry, to be efficiently supported.[6] By using a hybrid force, like the old dragoon, or the mounted rifleman of the future, the difficulty is partially obviated. Escorts.

As the question now stands, it is probably best to tell off a force of infantry and cavalry of those battalions and squadrons marching nearest the guns as an escort, to be used if required. These would not be detached to

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[1] "Die Taktik," Perizonius.

[2] The instances of defiles in the last war—such as crossing the Vosges, and Manteuffel's passage of the Côte d'Or—do not apply, as there was practically no resistance.

[3] "It will often find it necessary to go very much to the front, and perhaps to come into action very badly protected against the attack of an enemy."—Boguslawski.

[4] "Tactical Retrospect."

[5] The Austrian Regulations give 3 N.C. officers and 24 men, either of cavalry or infantry, as an escort for a battery—obviously too small a force to be of much use. French writers generally assign a squadron or company.

[6] "Des Soutiens d'Artillerie," Herbinger.

or march with the guns, but would accompany them at the order of their commander, when occasion arises. The compromise is unsatisfactory, as at the time of greatest need there would be the most difficulty in getting troops to perform this thankless office. The question is not yet properly solved; and till it is, the artillery of the future must play their prominent part subject to great risk.[1]

A passing glance may be taken at the specially organised advanced guards that will probably play an important part in future warfare.

cial ranced rds.

These will generally be formed of horse artillery batteries attached to the scouting cavalry of an army, or a detachment from the corps cavalry and artillery. The efficacy of their employment can, perhaps, best be realised by a description of the brilliant exploit of the horse artillery at the battle of Mars la Tour. A brigade of cavalry with four horse artillery batteries was ordered to advance towards Vionville, and compel the deployment of the French troops. The batteries galloped boldly ahead of the cavalry and unlimbered. The French outposts had scarcely signalled the approach of the Germans, when the encampments of both Forton's and Vallebregue's divisions were overwhelmed with shells. Thirty-four French squadrons and four batteries were so completely surprised that, though very superior in numbers, they retreated as quickly as possible. The "enemy was thus induced to deploy two entire *corps d'armée* on a line of battle facing west,"[2] (this being a totally false direction to give the front, as the Prussian main body was advancing from the south). The great defect these advanced guards labour under is that they require a powerful escort, and cavalry cannot always be spared for that duty.

Such then, briefly, are the considerations forced upon us by the theories of the most modern tactical writers, founded on the experience of the only wars in which the influence of modern weapons has been felt. The circumstances of civilised warfare have alone been considered, and continental nomenclature used for the units that England does not possess.[3] Undoubtedly, much of the reasoning does not apply to the warfare usually carried on by British troops. In the suppression of an Indian mutiny, or in the many *little wars* in which Great Britain is so frequently involved, a strict adherence to European tactics would probably be a mistake. Civilised warfare must, however, be always the model, to which the genius of a commander can make necessary variations in exceptional cases.

In the case of small bodies of troops, the detachment to an advanced

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[1] I cannot help thinking that the future place of the mitrailleuse will be among the batteries of artillery; not formed in batteries of its own, nor superseding a single gun, but disseminated among them. The French mitrailleuse used in the last war was nearly as heavy as a field gun; it had no lateral spread of fire, and its use was but imperfectly understood. When applicable to the ground, and efficiently used, the effect however was terrible, as witnessed in several of the battles. There are now similar weapons, in which lightness and spread of fire are combined; and which can discharge 400 to 500 shots a minute. Suppose one of these, drawn by two horses, was attached to a battery; it would be escort enough in itself. Where more than one battery is in position, effective cross fire could be maintained. With two-horse wagons for ammunition, the additional *impedimenta* to an army would be trifling; and I think this weapon, owing to its mobility and efficient defensive power, would be the most effectual escort to the artillery of the future. Whether they should further play a more prominent part in war, is beyond the present question.

[2] "Franco-German War," Borbstaedt.

[3] Army and corps.

guard of a fraction as large as has hitherto been laid down, would be obviously a mistake. In fighting against a semi-civilised enemy, again, the rules of tactics require considerable modifications—variations, to be determined by local circumstances. It may be assumed, on the whole, that advanced guards, in the warfare usually carried on by English troops, will be, as heretofore, simply bodies affording the same security to an army on the march that outposts do a stationary one. Cavalry will probably be employed far more boldly as a scouting and reconnoitring force, but the *rôle* of artillery in advanced bodies continue to be comparatively unimportant.

The consideration of a European army has alone been dealt with, and the deductions are meant to apply solely to British troops when engaged in continental warfare.[1]

It may be argued that the teaching of the German school has been too much adhered to. Without assuming that everything is good that emanates from the Prussian Bureau, it cannot be denied that Germany initiated the modern reforms in tactics, and still preserves the lead. The close study of war requirements which has led to the astounding victories of the North German Confederation, cannot be ignored. There are several mooted questions in tactical detail which are still open to discussion, and of which future experience must sift the value; but the main principles it has been the subject of this essay to elucidate must, for the present, be deemed reliable. The German school has certainly been followed; but where else is instruction to be gained? Continental nations are in every instance following its steps, and England must perforce do the same; taking care to recognise that, under the peculiar circumstances of her national position, a modification of continental forms of warfare will be, in general, necessary.

30th March, 1871.

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[1] The English army is calculated, at present, on the supposition that a subsidiary force, completely equipped, of 60,000 men, should be, on emergency, available for continental service.

Will shortly be published.

RECORDS

OF

THE HORSE BRIGADE,

FROM

ITS FORMATION TO THE PRESENT TIME.

BY

JOHN EDWARD MICHELL,

LIEUT.-COLONEL ROYAL HORSE ARTILLERY, BREVET-COLONEL.

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USE OF RIFLED FIELD ARTILLERY.

Translated by permission from "Les Conférences Militaires Belges."

By Lieut. C. M. SMITH, R.A.

The introduction of rifled guns into the service has not taken place without influencing to a certain extent the tactics of field artillery, though, at the same time, it must be borne in mind that most of the *general* principles on which the tactics of this arm are based have undergone no radical change.

Although the adoption of rifled artillery may be traced to a comparatively distant date, still, it is to the most recent campaigns that we must look, if we would fully appreciate the immense importance of this arm in modern warfare. It is from a study of the examples which such campaigns afford, and by a perusal of the works of those military writers, who have most recently treated the subject, that we venture to offer for consideration some of the rules relative to the use and working of the new arm.

Properties of the Belgian Field Artillery.

The following considerations may be useful in conveying some idea of the sphere of action of our rifled field guns.

At a distance of 800 mètres,* the mean error in range of the projectile is 11 mètres, and its lateral deviation about 1·2 mètres. The angle of incidence is only 2,° and it is therefore self-evident what a murderous effect would be produced by the fire of rifled artillery at that distance.

At a range of 1600 mètres, the error is about 12 and the lateral deviation $1\frac{1}{2}$ mètres, the angle of incidence being in this case 5.° The rectangle of which this error in range forms one side, and the lateral deviation the other, represents pretty nearly the space occupied by a gun or wagon with its train, and hence we may affirm that the fire of rifled artillery against artillery is efficacious up to 1600 mètres. At 1800 mètres the errors in range and lateral deviation are 14 and 2 mètres respectively, and at this distance a battalion of infantry, massed in column, would be struck by the majority of the shots. At a range of 4000 mètres the above errors are 20 and 5 mètres respectively, but as the angle of incidence is no less than 22,° the explosive effects of the projectiles are comparatively feeble. It follows from the preceding data that rifled field guns are available against infantry, cavalry, or artillery, up to a distance of 1800 mètres, or thereabouts.

Over 2000 mètres the chances of striking the object fired at become gradually less, owing to the increase in the angle of incidence and con-

* 1 mètre = 39·3708 English inches, or a little over 1 yard.

sequent diminution of dangerous ground, but the accuracy of the range seems to be greater than at shorter distances. In short, it may be said that rifled guns are effective up to 4000 mètres when used against objects covering some considerable extent of ground.

The projectiles used with rifled guns consist of common shell, shrapnel, and case. Common shell have a considerable percussive force, even at long ranges, which is attributable to their weight, shape, and the small loss of velocity to which they are subject. In addition to their percussive force, the effect due to their explosion must be added. These projectiles produce a great effect against troops, more especially when the latter are in column, as the splinters are projected right into the depth of such columns.

Another advantage possessed by common shell is noticeable in the fact that they can be fired at great angles of elevation, and with small charges. This species of fire, which is remarkably accurate, enables you to utilize the explosive power of the shell against troops placed in intrenchments, villages, and houses, or sheltered by the undulating nature of the ground. Shrapnel are particularly effective against troops manœuvring on level ground, and are consequently admirably suited for use against cavalry and horse artillery, which act, for the most part, on ground of a like nature.

It must, however, be remarked that at long ranges the velocity and percussive force of shrapnel bullets are too weak to admit of their producing a great effect, and it is owing to this consideration that the Belgian regulations limit the use of shrapnel from rifled guns to distances not exceeding 1800 mètres.

Case can be advantageously used up to 400 mètres, but beyond this distance they are seldom employed, and it is then preferable to use common shell or shrapnel. Case are principally used to repulse an attack of cavalry.

Proportion of Guns to Men.

It seems to be pretty generally admitted by those who have written on artillery organisation that the relative proportion of this arm to the total strength of the army depends principally on the configuration of the ground in which the theatre of war is laid, and also on the kind of troops employed. In a country like Belgium, which is composed for the most part of level plains, or only intersected by obstacles of such a nature as can be easily surmounted by cavalry and artillery, a large force of the latter arm may be employed with advantage, for, on such ground, a considerable number of guns can deploy without difficulty, and vigorously second the attack of the other arms.

In fixing on the proper proportion of guns that should accompany an army in the field, the nature and quality of the troops composing it must also be taken into consideration. In an army formed of soldiers who are comparatively young and uninured to war, or one in which the cavalry element is inferior, either as regards its numbers or quality, it is essentially necessary to have an artillery force of such strength as to

supplement the weakness of the other arms. The same dictum holds good in the case of opposing a courageous and warlike enemy.

The preceding considerations seem to point to the Belgian army as being one in which the proportion of artillery to the other arms ought to be above the average of other countries. This proportion has varied from time to time and has, in the armies of some European powers, reached as high as 7 guns per thousand men. The usual number is, however, 3 guns per thousand men, and this is the figure given by such authorities as Grevenitz, Decker, Okanneff, Lebourg, and others, and should, especially now-a-days, be considered as the lowest admissible proportion of guns to men. This recognised proportion seems to have been in no way affected by the introduction of rifled guns. Colonel Taubert, in his able work on rifled field artillery, holds the same view, and three guns per thousand combatants was very nearly the proportion employed by the Prussian and Austro-Saxon armies in the last war in Germany. The Austrian artillery was composed solely of rifled guns, and though it is true that in other German armies, there were a considerable number of smooth-bores, these latter were replaced by rifled guns at the conclusion of the campaign. Lastly, the field artillery of the Northern Confederation, so far from having been reduced, has been augmented.

Distribution of the Artillery in an Army.

In armies organised in "army-corps," the usual distribution of artillery is to give two field batteries to each division of infantry, and one horse battery to each division of cavalry. These batteries form an integral part of the divisions to which they are attached. The plan of attaching artillery to brigades should be avoided, except in the case of any single brigade acting in an isolated position, when one battery should be awarded to it.

Indepently of its *divisional* artillery, each army-corps should have a reserve of three or five batteries (according to the number of divisions of which it is composed), of which one or two should be horse artillery.

This is the distribution adopted by France. In the New Prussian system, the *divisional* artillery consists of four field batteries to each division of infantry, and two horse batteries to each division of cavalry. The object of this is to render it unnecessary for divisions to have immediate recourse to their reserve artillery the moment the engagement becomes serious. The General commanding is also empowered, should he deem it advisable, to reduce the number of batteries assigned to divisions, and in such cases the batteries judged superfluous are to be transferred to the reserve artillery. As the number of guns in a Belgian battery is eight, while in a French or Prussian one it is only six, a middle course is pursued in the distribution of our artillery, and two field batteries are given to each division of infantry.

In addition to the divisional batteries and those attached as a reserve to each "corps," an army in the field should also have a *general reserve* of artillery. This should never be used, except to strike some decisive blow, and then only by the express order of the Commander-in-Chief of the army.

General Principles as to the Use of Artillery.

The general principles regarding the employment of artillery in the field, which have been laid down by all military writers for the last half century, have been in no wise affected by the introduction of rifled guns into modern armaments. They may be briefly enumerated as follows:—Artillery fire commences an engagement, supports it, and paves the way for the final "dénouement." Artillery protects such troops as are exposed to the enemy's fire; acts, at times even singlehanded, in the pursuit, if the other arms are deterred from doing so by obstacles of ground, &c. It is also of great use in covering the retreat of an army. Guns, to be of use, should always be placed in the best possible positions, and in intimate connection with other troops, and to this end the officer commanding the artillery should at all times be perfectly acquainted with the intentions of the General commanding, and of the object sought to be attained by him, in order to act the more effectively in concert with him. He ought, therefore, to be always about the person of the Commander-in-Chief of the army, who will thus be able to interchange ideas and opinions with him.

Officers commanding divisional artillery should remain in the immediate vicinity of the generals of the divisions of which their batteries form a part, and should never repair to these latter unless their presence is absolutely required. Their orders should be conveyed to the captains of batteries under their command by a divisional adjutant.

We have seen that the various subdivisions of artillery accompanying an army are made up of batteries. The battery is the tactical unit, and consists of a certain number of guns, which number has been determined on with a view to all the possible requirements of a campaign. The separation of the component parts of a battery is therefore reprehensible, and although a half battery may be often usefully employed alone, the isolation of a smaller fraction is to be condemned, save in exceptional circumstances, such as the defence of a dyke or causeway, or the destruction of a barricade, when the temporary separation of a *couple* of guns is admissible.

Influence of the Nature of the Ground in determining the Position of Field Artillery.

The ground in front of a battery should be as open as possible, in order to admit of the range being accurately judged, and of the effect upon the enemy being duly ascertained. It follows from this that the most commanding positions on a field of battle should be occupied by guns; care must, however, be taken that the elevation of such positions is not so great as to render the fire "plunging," or to prevent the foot of the slope from being thoroughly swept by it.

Another advantage gained by choosing an elevated position for a battery is that you can screen your guns behind the crest of the eminence in such a way as only to expose the muzzles.

In fixing on a site on which to place guns, stony ground should be avoided. Marshy ground, or such as is cut up by furrows, is useful in front of a battery, as it may stop, or at all events turn aside, many of the

enemy's projectiles, and thus prevent their reaching the guns. A position should be chosen which will render it difficult to the enemy to judge the true range and consequently deprive him of great accuracy in his fire, and therefore it is never wise to place a battery in a position in the vicinity of which there are such prominent objects as houses, mills, or trees, the respective distances to which he may have had a previous opportunity of calculating. An instance in support of the above rule is to be found in one of the battle-fields of the Bohemian Campaign. A Prussian battery had just come into action, and was about to open fire, when suddenly the ground on which it stood was torn up by a perfect hailstorm of shell.

These unwelcome visitors proceeded from an Austrian battery, which had been enabled, thanks to a known mark near the Prussian position, to hit off the range to a nicety. It is needless to add that the Prussian battery changed its ground with all possible speed. The smallest accident of ground, such as a ravine, or thicket, or hedge, will often be sufficient to shelter a battery from the enemy's fire, and thus become of paramount importance. Of course, such obstacles must not be of a nature to admit of the enemy approaching near the guns with impunity.

The choice of a good position, on which to bring artillery demands a practised eye and great discernment, and captains of batteries should use every means in their power to cultivate the acquisition of such qualities. In addition to the above-mentioned considerations, it is imperative that the position should be easily accessible on both sides, so that the guns may be able to advance without delay, in case of success, and also have an assured means of egress in the event of their being compelled to retire.

Position of Artillery in the Line of Battle and its place on the March.

The practice of placing artillery in the intervals between other troops is to be deprecated, as such a disposition hampers the movements of the latter and compels the guns either to suspend their fire or to be constantly changing their ground. In certain exceptional circumstances, to take the case, for example, of an army occupying a position where it is foreseen that it will not have to act on the offensive, the artillery may be distributed along the whole line of battle. At the commencement of an action the divisional artillery is placed on the wings, and from one to two hundred mêtres in advance of the division to which it belongs, to protect the deployment of the latter.

As soon as the infantry become engaged, the guns cross their fire in front of it, taking care to keep out of the range of the fire of the enemy's infantry.

Should there be any tenable position in the immediate vicinity of the battle field, from which an oblique or slant fire can be opened on the enemy, such ought to be occupied by artillery in preference to any other, even though it be a little removed from the ground occupied by the other arms. The great range of rifled guns will frequently admit of such

a position being taken up, but at all times the batteries must be supported by a sufficient complement of other troops.

The position of artillery in the line of march of an army corps should be such as to ensure its early arrival on the field of battle, and to enable it at once to enter on its proper functions. It often happened in the late campaign in Bohemia, that the Prussian artillery of reserve was far in rear of the last division, and consequently unavailable when the opportune moment for using it arrived. The artillery of the advanced guard had single-handed to enter the lists against an overwhelming artillery fire on the part of the enemy.

It is but fair to state that this error was avoided by the Prussian guard at Sadowa, for the bulk of the cavalry and all the artillery of reserve were immediately in rear of the advanced guard of the 2nd division, and it was thus possible to bring the reserve artillery of the guard into action at the right moment. Some of the greatest victories of Frederick II. were gained by the application of the above mentioned principle.

At the battle of Leuthen, which was fought on the 5th December, 1757, that great General had in action, from the very commencement of the engagement, a large number of 12 and 24 pounders, which had been taken, only a few days previously, in the arsenals of Glogau. These guns contributed in great measure to the victory.

It would be difficult to name a battle in which Frederick the Great did not make use of all his heaviest guns, and almost invariably with the greatest success.

Tactical Rules for Artillery.

Artillery ought not in general to open fire until it is within easy range of the enemy, that is to say, at a distance at which not less than half the number of shots fired may be expected to take effect.

Distant cannonades should be avoided, as they produce little or no effect, and only waste ammunition. It is always the tendency of artillery to commence its fire too early.

Attention was drawn to this fact by Frederick II., and Blücher, in an order of the day dated 2nd July, 1815, impresses strongly on the Prussian artillery the necessity of reserving its fire until within a moderate range of the enemy. The same fault is noticeable in the campaign of 1866, where guns frequently opened fire at distances of 2500 and 3000 mêtres, and in some cases even beyond the last-named range. Artillery fire should be confined to distances at which the effect produced is discernible with the naked eye, and this axiom especially holds good in offensive operations.

In the case of batteries acting on the defensive, the above rule may be somewhat relaxed, as the guns will probably be in positions highly advantageous for ascertaining the exact range by means of known landmarks, &c. (as we have seen the Austrians did Sadowa); but even then 2500 mêtres should be the maximum distance at which artillery should open fire.

From 800 to 1800 mètres rifled guns can fire with effect: at the former range with terrible certainty; but if it is a question of striking some grand decisive blow, artillery ought not to hesitate to advance still nearer the enemy.

At the outset artillery should deliver its fire somewhat slowly, gradually increasing in rapidity as the range becomes more accurately known, but always with such an interval between the rounds as will admit of the effect of each projectile being duly observed and noted. A too rapid fire is only productive of a great expenditure of ammunition without any corresponding results.

When case is used the firing should be as rapid as possible.

So far we have said nothing of *volley* firing. This would be extremely effective, when the united strength of several batteries is brought to bear on masses of the enemy.

In order to accustom gun detachments to determine the range with accuracy great attention and pains should be bestowed on this portion of their drill. Should the range not be well hit off, or the effect produced be apparently small, the fire should be slowly continued; when within easy range it should increase in rapidity, and finally attain its maximum celerity when the decisive blow was to be struck.

As a general rule the fire of artillery ought to be directed against the infantry and cavalry of the enemy and *not* against the artillery. As an example of this, the affair of Rosdorf may be cited, where a Prussian rifled battery, placed on an eminence, kept up a continuous fire on the column of Bavarian infantry, which were on the march from Rosdorf to Wiesenthal, without replying to the fire directed on it by the enemy's guns. The result was that the Bavarian division was compelled to retreat. Instances may occur where the enemy's fire is so destructive as to render an artillery duel absolutely necessary.

Guns should be laid on some definite object, and it is only by a concentration of fire that great results are obtained.

It was in consequence of failing to recognise this principle, that, at the battle of Gros-Görschen, which was fought on the 2nd May, 1813, seventeen Prussian batteries failed to produce any result at all commensurable with the number of pieces engaged. Except under very exceptional circumstances a battery ought not to change its position, unless for the purpose of advancing or retreating 400 or 500 mètres at least.

So far we have treated of the conditions of fire in the case of a battery occupying a tolerably advantageous position, and out of range of infantry fire. When, however, the distance is reduced, and the other arms come into play, batteries must be so placed as to render an effective support to these latter, without at the same time impeding their action.

The officer commanding a battery must judge the favourable moment for bringing his guns into action, and must also endeavour to conceal them as much as possible, in some sheltered spot, until such time actually arrives.

The battery should then be deployed, and advance at a brisk pace towards the position to be occupied. Each gun will thus present only a small moveable mark to the enemy. The wagons forming the second

line of a battery should be removed from the enemy's fire sufficiently to prevent the disastrous effects of an explosion.

Finally, a few words with regard to the supports which are necessary to protect guns on the line of march, or in action. Their object is to render artillery independent; to preserve it from the fire of sharpshooters, and to guarantee its security against attacks in flank or rear. Supports may be dispensed with when a battery is already sufficiently protected by the troops in its immediate vicinity. The escort for guns is composed of infantry or cavalry, according to the nature of the ground, and the object to be accomplished. A company, or squadron, is usually considered a sufficient escort for one battery. Such troops should keep close to the guns, in order to protect them if menaced, but should avoid exposing themselves to the enemy's fire, by taking every advantage of the configuration of the ground.

Independently of the escort, artillery should at all times be able to count on assistance from neighbouring troops in case of emergency.

The use of Artillery in offensive and defensive Engagements.

The usefulness of a battery in the field varies directly with its mobility and the effect it is capable of producing. In both these respects field artillery has been a large gainer by the introduction of rifled guns. The smallest of our rifled guns, the "canon de 4," is far superior in destructive effect to the smooth bore "canon de 12," which was formerly the field gun of largest calibre, while the rifled "canon de 6" surpasses in mobility even the lightest of the old smooth bores.*

Batteries armed with the "canon de 4" are employed in the divisions of the line, and those whose armament consists of the "canon de 6" are generally attached to the divisions of reserve. The arming of batteries of horse artillery with the rifled "canon de 4" is one of the many improvements introduced into that branch of the service, giving it, as it does, a very much lighter piece, together with an increased destructive effect of fire. Batteries of horse artillery are generally employed either with the advanced and rear guards, or are attached to the cavalry of reserve, or lastly are kept as a general artillery reserve which shall be in readiness to give prompt assistance to any threatened point in the line of battle, to oppose rapid flank attacks, or to pursue the enemy. Let us now consider the maxims which should guide the conduct of artillery acting on the defensive. As soon as the advanced guard of an army is engaged, the divisional commanders of artillery should go to the front for the purpose of examining the ground and making their dispositions accordingly. This should be done with the utmost care. Batteries should remain in the vicinity of the infantry, in order to avoid the danger of being swept away by any sudden onslaught of the enemy. As already noticed, long range firing is to be deprecated. Firing should commence at about 2500 mêtres against troops in column, and at about 1,800 mêtres against those in line. At the same time it must be

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* The respective calibre of the "canon de 4, de 12, and de 6" is 3·071, 4·71, and 3·662 English inches.

remembered that guns are not to remain long in action at the above distances, but are to advance as rapidly as possible to closer quarters.

The fire of the artillery of a division should be principally directed against the enemy's infantry and cavalry, and not against his artillery, unless the fire of the latter is so destructive as to hamper the movements of the troops, or if it is a question of carrying a position defended by artillery. In cases of such a nature it is impossible to decline an artillery duel, but it should be carried on at as short a range as possible. At the crisis of the fight the fire of the batteries of divisions and of those of the reserve also should be concentrated on the principal points in the line of battle. Common and shrapnel shell will be used for this purpose; case could only be employed by exposing the guns to a heavy fire of small arms, which should be carefully avoided; and as far as effect is concerned, common and shrapnel shell will answer the purpose equally well. It happened on more than one occasion, in the campaign of 1866, that several well-directed shells, falling in the midst of a column of cavalry or infantry, completely dispersed it, and, as a particular instance, we may cite the battle of Sadowa, where Captain de Werder's Prussian battery of rifled guns utterly routed a battalion of chasseurs formed in close column, at a range of 750 mètres, this result being obtained with only four shells. Again, a few well-directed shells, fired at a rifled battery of the Army of the Maine, put to flight five regiments of Bavarian cavalry. Lastly, should the attacking columns waver, the guns should concentrate their fire on the enemy's infantry, and continue firing without interruption until they are clouded by the smoke of their own infantry advance. They will then suspend their fire and await the issue of the attack, ready either to aid in the pursuit of the enemy or to cover the retreat of its own troops.

In the defence of a position it is a matter of primary importance for artillery officers to be thoroughly acquainted with the configuration of the ground, and also, if possible, to ascertain the distances of all the principal objects which the enemy will be forced to occupy in his advance. A knowledge of these details will enable the Captain of a battery to give increased efficacy and precision to his fire. We know that at the battle of Sadowa the Austrian artillery had carefully marked out the field of battle before the arrival of the Prussians, and that their artillery fire acquired, in consequence, the most deadly precision. Every inequality of ground should be taken advantage of to obtain cover for guns, and in defensive combats it is often very desirable to construct epaulments, or at all events to throw up sufficient earth to shelter the pieces and their detachment.

The portable "aide mémoire," in use by the French artillery, recommends shelter trenches for guns destined to remain in position of the following construction: a parapet of earth about $0{\cdot}80^{m}$ high in front of the guns, with a ditch $0{\cdot}50^{m}$ to $0{\cdot}60^{m}$ deep at either side, to afford shelter to the gunners. The Austrian artillery entrenched their position at Sadowa, and went so far as to add traverses and powder magazines. A few hours suffice to throw up works of such a nature, while the security they give is immense. Care must, however, be taken that their construc-

tion is of such a nature as not to hamper the movements of the guns should they be required to assume the offensive. The guns of largest calibre should be placed at the most important points of the position; they should open fire at long ranges on the enemy's line of march, and engage his artillery, when the advantage will be all on the side of the party acting on the defensive.

In proportion as the enemy advances, the artillery will direct its fire on the heads of the opposing columns and no longer on the guns, save at favourable opportunities, when, for example, the latter attempt to unlimber for action, or present an exposed flank. When the enemy's artillery fire begins to preponderate, the reserve artillery should be brought into action and placed as much as possible on the flanks of the enemy's guns, so as to enfilade and dismount them; this method is better than simply reinforcing the artillery of the line of battle. At the same time an attack should be made on the columns of advance, by seconding the action of the reserve artillery with vigorous charges of cavalry. Should the cross fire from the artillery of the line of battle in front and the reserve artillery on the flanks be insufficient to check the enemy's advance, recourse must be had to case, with which a heavy fire must be kept up, as under no circumstances ought artillery retire before infantry. If need be, they should be sacrificed for the general safety of the whole army.

In the event of the army being obliged to retire, the artillery should support such a movement by taking up its ground successively in the most advantageous positions in rear. Guns should retire in *échelon*, that their fire may never be entirely interrupted. When infantry form square to receive cavalry, artillery should take up its position in rear of the squares, or in the intervals between them, in order to be enabled to cross its fire with that of the squares, and thus give effective support to the infantry. In case of a general retreat, a rear guard of all these arms must be formed, and for this purpose the artillery must supply its quota of guns. For such a service, rifled "canons de 4" would seem to be the most suitable, as they are light and carry a large quantity of ammunition in the limbers and wagons. At the same time, if the retreat is to be made over a country which it is desirable to defend to the last extremity, and which affords good positions for artillery to act in, the artillery of the rear guard should be supplied with batteries armed with the "canon de 6." Lastly, if the country is level and the rear guard composed principally of cavalry, horse artillery should be attached to it.

It remains to be seen how horse artillery should act in conjunction with cavalry.

Cavalry ought more than ever to avoid remaining exposed to fire, and, therefore, all horse artillery and cavalry combats should be offensive ones, even when it is a defensive engagement that is being fought. Horse artillery should remain in action as short a time as possible, and should avoid distant cannonades, unless it be necessary to give the cavalry time to come up. As soon as the cavalry attack has been decided on, and the aim thereof well determined, the horse artillery should advance to within from 800 to 1200 mètres of the enemy, which is the

distance at which their fire will be most effective. Such a movement should be made while the cavalry are still in column, or are deploying for the attack. Horse artillery must not allow itself to be turned away from the completion of its proposed end by the fire of the enemy's artillery; neither should it occupy itself in providing against dangers from which it is the duty of the cavalry to screen it. It ought to continue its fire till forced to cease by the interposition of its own cavalry between it and the enemy. The officer commanding the cavalry should strive so to manœuvre as to shackle as little as possible the action of artillery; this, however, owing to the nature of the ground and other considerations, is not always possible. Should the cavalry attack prove successful, the horse artillery will by its fire augment the confusion of the enemy.

Since the introduction of rifled guns, some have asserted that horse artillery, when acting with cavalry, should advance to close proximity with the enemy, in order to deliver its fire of case, as was the custom in the days of smooth-bores. We are of a contrary opinion, for this reason, that the guns would be exposed to the enemy's fire without producing any corresponding effect; it is only against demoralised infantry that this species of fire can be successfully employed.

USE OF THE ARTILLERY OF RESERVE.

Employment of Grand Batteries.

Reserve artillery is intended to support the weak points in a line of battle, and second the efforts of the cavalry and infantry of reserve. While, on the one hand, divisional batteries are principally employed as an auxiliary arm, the artillery of the reserve plays a much more prominent part, and ought never to be brought forward except for the purpose of striking some decisive blow. In a few cases, it is true, batteries of reserve may be used in support of the divisional artillery, as, for example, when a division is acting separately and is for long deprived of any extraneous aid, or if its artillery is so weak as emphatically to demand an accession being made to its strength. Before coming into action the artillery of reserve should be posted near the troops of the reserve, and formed up in close column of batteries, so as to occupy as little ground as possible. If it is not sufficiently sheltered, a line of formation must be chosen in preference; but in all cases it must not be deterred by the fear of being struck by a few stray projectiles from taking up a position at a moderate distance from the enemy. Reserve artillery should be placed either in advance or on the flank of the reserve troops, but never, if possible, in their rear, so as to be unimpeded in its action. The lines of communication between the reserve artillery and the principal points of the line of battle must be carefully selected, in order that no delay may occur in moving a battery to whatever spot requires its presence. The artillery of reserve should be brought into action at an increased pace, by batteries, half-batteries, or even divisions, should the nature of the ground demand it, and then deploy as quickly as possible on the position assigned to it. In its case more especially should distant

firing be avoided, and as near an approach as possible be made to the enemy, provided always that the range is beyond that of the effective fire of infantry. Should the enemy's ranks be intact and well provided with artillery it may sometimes be necessary to engage his artillery first, and subsequently advance rapidly to closer quarters, to confront the remainder of his forces. It is an error to imagine that rifled batteries of reserve should use case, except to repulse a sudden charge of cavalry.

The entry into action of the reserve of cavalry and infantry will be sufficiently prepared for by the fire of common and shrapnel shell. It is unnecessary and moreover inexpedient to place all the batteries of reserve in the same alignment, as by doing so they may be exposed to the enemy's enfilade fire. All that is required is, that their fire should converge towards the point which it is desired to penetrate.

It is often right to leave considerable intervals between such batteries; when, for instance, such a disposition will enable you to take the enemy's columns in flank, or when it is desirable to command a large extent of ground with a view to facilitating the offensive operations of an army. Finally, it must be borne in mind that the movements of the reserve artillery, as well as their position in action, must be protected by infantry or cavalry.

The simultaneous employment of a number of batteries, massed together under one command, has been often successfully applied. They are generally composed of the Reserve Artillery of Corps d'Armées, and the general reserve artillery of the whole force.

In some instances a few batteries drawn from the divisional artillery are also added, as was the case at the battles of Friedland and Wagram; but recourse should never be had to these last except in the most emergent circumstances, as the moralé of troops is very liable to be affected by severance from their guns.

The object of massing guns is to strike a decisive blow, to pierce the centre of the enemy's line, to pave the way for a grand flank attack, to cover the passage of a river, to cannonade an entrenched position, to repulse an attack in force, to bring an engagement to a close, or re-establish it on a firm basis, and finally to cover a retreat.

A few examples will suffice to show the mode of employing these grand batteries and the advantages gained thereby. Attacks on a large scale, directed against the centre of the enemy's line, or undertaken at the right moment against troops already shaken, have often determined a victory. Thus at Wagram, the Austrian front was too much extended, while Napoleon occupied a central position. Taking advantage of this circumstance, the Emperor resolved to pierce the enemy's centre, although his own left, under Boudet, had been driven back by the corps of Klenau and Kollowrath, and the bridges over the Danube, which formed his line of retreat, were at the time seriously menaced. To prepare the way for the grand attack against the centre of the Austrian army, 10 batteries of the artillery of the guard and the divisional batteries of such troops as were in the centre of the line of battle were massed together. This enormous battery, the command of which Napoleon entrusted to General Lauriston, was originally composed of 60 pieces, which, under the protec-

tion of the cavalry, advanced at a trot in column of half-batteries, with the intention of deploying when at 400 mêtres from the enemy. Of these 60 pieces, 45 only succeeded in getting in position, the remaining 15 having been placed "hors de combat" during their advance by the fire of the enemy's artillery. By degrees this gigantic force was increased by reinforcements till it numbered 100 guns.

After a terrific cannonade, which lasted about half-an-hour, Napoleon ordered the general attack, and then this huge battery, opening out to the right and left, presented a free passage for Macdonald's column, at the same time affording it effectual support against the battalions of the enemy which threatened its flanks.

The battle of Friedland offers a striking example of the plan of massing artillery.

The French artillery, commanded by Senarmont, took up a position at a distance of 450 mêtres from the enemy, from which it advanced, after firing 5 or 6 salvoes, to 200 mêtres, and there opened a most deadly flank fire. In order to hasten the defeat of the Prussians, Senarmont issued orders to cease firing at the enemy's artillery (although the latter was taking his own guns in flank), and to advance to within a range of 100 mêtres and open fire with case. The Russian cavalry was immediately put in motion to support the shattered columns of its infantry, when Senarmont, by a change of front, directed a concentrated fire from all his pieces against it, and caused its precipitate retreat at the second round.

At the battle of Gross Beeren, which was fought on the 23rd of August, 1813, between Oudinot's corps, and the Prussian 3rd Army Corps under Bülow, 55 Prussian guns were massed, and having deployed in front of the infantry, opened fire at 1303 mêtres. They subsequently advanced and took up fresh positions in succession. They fired altogether 2095 rounds. The reserve artillery afforded them valuable assistance, and the French artillery, although advantageously placed, was obliged to retire. This example of massing guns is one of the most remarkable in the annals of the wars of the first empire.

At the battle of Kalzbach, which was fought on the 26th of August, 1813, the Prussians had 104 pieces of artillery in line, which fired 3600 rounds. In this instance the lighter natures of guns were specially useful, as, in spite of the heavy state of the ground, which had been deluged by torrents of rain, they were able to move with comparative rapidity. The whole of the artillery of the 4th Prussian Corps and a portion of that of the 1st and 2nd Corps, comprising in all 118 pieces, were engaged in grand batteries at Waterloo. These guns fired 4800 rounds and held in check 32 French battalions and the Imperial Guard, which were advancing to prevent the junction of the Allies.

At the battle of Solferino a French battery of 42 guns, furnished by the divisional artillery and the reserve artillery of the 4th corps, enabled a stand to be made for a long time against superior numbers. The latest campaigns in which rifled artillery have been used prove that the plan of massing guns is far from becoming obsolete.

At the battle of Sadowa the advance of the 1st Prussian army against the centre of the Austro-Saxon army was prepared by bringing grand

batteries into action on the line of the Bistriz; and although the Austrian artillery was twice as numerous, their fire was silenced, and they were compelled to beat a retreat. It was artillery in mass which opened the ball at Sadowa, in the great flank attack made by the 2nd Prussian army under the Crown Prince, while the 1st army and the army of the Elbe engaged the Austrians in front and on the left wing. On the heights of Horonowes 90 pieces were in action, and the difficulties they had to surmount were enhanced by the fire of 100 Austrian guns, which ploughed up the ground around them with a perfect hailstorm of shells.

Disdaining the fire from these pieces, the Prussian artillery concentrated its own on the enemy's reserves which were in sight. At a later period the same batteries gave timely aid to their infantry, which rallied under their protection at a moment when they were forced to give way before the repeated attacks of the Austrian reserves. The guns opened such a tremendously effective fire on the front and flanks of the attacking columns as to cause them to retire in the utmost confusion.

Using Artillery in Pursuit and Retreat.

After a victory, the artillery, if properly handled, may convert the retreat of the enemy into a rout. To attain this result, the horse artillery should advance rapidly on the enemy's flanks, and endeavour by their fire to prevent his taking up a fresh position. They must, at the same time, avoid being drawn on too far in the heat of the pursuit, for the retreat of the enemy may, after all, be only a feint to entrap his adversary. Artillery must also be careful in a pursuit not to interfere with the action of the other arms, more especially with that of the cavalry. In case of a retreat being necessary, the artillery which is in line must conform to the movements of the other troops, and retire in the most perfect order in *échelon* of batteries or half-batteries. It will come again into action on the most favourable ground, and hold out as long as possible, even sacrificing itself, if needs be, to assure the safety of the armies.

The batteries of reserve, those of heaviest calibre if available, should take up positions on ground previously determined on to cover the retreating troops and allow of their rallying, or traversing defiles, &c. Vigorous attacks by the horse artillery and cavalry will sometimes render the enemy more cautious and stay the ardour of the pursuit.

Eight Austrian batteries of reserve acquired immortal fame at the battle of Sadowa by the way in which they covered the retreat of the army. These batteries took up in succession three well-chosen positions, which they held with such determination as to enable the Austrian army to cross the Elbe with comparative facility, a movement which, without their protection, would have been transformed into the most frightful rout.

Use of Artillery in the attack and defence of a village, an entrenched position, or a defile, and in the passage of a river.

A village often serves as a "point d'appui" to a line of march, and becomes the scene of many a desperate struggle. In the defence of a

village, it would be advisable to place batteries on both flanks to rake with their fire the columns of attack. A sufficient force of artillery, kept in reserve behind the village, would be useful in opposing any attempt the enemy might make to turn the position, and also in preventing them from debouching in rear of the village, should they succeed in obtaining possession of it. In the attack of a village the first business of the artillery is to endeavour to silence the fire of the batteries opposed to it. The village should then be shelled, and all barricades and walls of enclosure be destroyed. By firing shell and shrapnel at high angles of elevation the positions held by the enemy's reserves behind the village may be rendered untenable. Lastly, it should concentrate its fire on the points towards which the columns of attack are directed. In the campaign of 1866, rifled artillery played a very prominent part in the attack of villages. Eight field and two horse artillery batteries, belonging to the divisional and reserve artillery of the 5th Prussian corps, prepared the way for the attack of the village of Skalitz, and pursued the Austrians after its capture.

The left wing of the Austro-Saxon army at Sadowa rested on the village of Problus. This village, which was defended by the Saxons was attacked by the 14th Prussian division, which, at the time of the assault, had to traverse a space of 1500 mètres under the fire of two Saxon batteries. These batteries were opposed by the 12-pr. smooth-bore and three rifled batteries. The village was vigorously cannonaded with shell and shrapnel, and the assault was successful, despite the tremendous fire of the defence The attack on the village of Schweiaschüdel was preceded by the fire of three rifled batteries, three rifled 4-pr. batteries, and a horse artillery battery.

The wars of last century, and even those of the first empire, abound with examples of entrenched positions—witness the battles of Neerwinden, Malplaquet, Fontenoy, Jemmapes, Montemke, Millésimo, and the Moskowa. Redoubts or other fortified posts, which can often be constructed in a single night, are often very useful.

Fortified field works, judiciously placed, far from paralysing the action of an army, favour offensive movements, as was the case at Fontenoy, and Monteuille. The long range and accuracy attained by modern arms of precision constitute an additional reason for keeping men as much as possible under cover, and for this reason, if for no other, a good system of field works would seem to confer an incalculable benefit. The use of artillery in the attack of a fortified post is to silence any guns placed either behind embrasures or "en barbette," and to effect a practicable breach. Shells fired with a small charge are thrown into the interior of the work to harass the defenders and destroy any blockhouse or redoubt which may exist within. Should time and the nature of the ground permit, the guns should be sheltered by an epaulment, and just before the assault the artillery should concentrate its fire on the principal breach.

The artillery of the defence, on the other hand, should make it their first business to acquaint themselves thoroughly with the distances of the various positions which the enemy must occupy. Its fire should be

mainly directed against the enemy's infantry. The guns should be run back behind the ramparts when the enemy's fire is in the ascendant, and brought into action again when the assailant is making his dispositions for the attack. As soon as ever the latter approach the counterscarp, he should be received with a heavy fire of shell, shrapnel, and even case.

If a defile has to be defended, the guns should be placed so as to cross their fire on the defile and sweep it in the direction of its length. To prevent the enemy debouching from the defile, should they succeed in making themselves masters of it, a concentrated fire at a close range should be opened on the side of egress. Should the nature of the ground permit of any flank movement being made by the enemy, to turn the position, batteries of horse artillery, kept in reserve for the purpose, ought to be available to frustrate or check it.

Epaulments are sometimes constructed a little in advance of a defile, and guns placed in them for its defence, should the enemy attempt a passage.

For example, in the Crimea, after the battle of Traktir, the French constructed several field works, and among others an epaulment for twelve 12-pr. howitzers, which was thrown up opposite a bridge which existed in the neighbourhood. The epaulment was distant from the bridge about 700 metrês. Should it be a question of forcing the passage of a defile, the artillery of the attacking force should open fire, if composed of rifle guns, at a comparatively long range, and endeavour to silence the pieces which defend it. If the position be carried, light 4-pr. batteries should accompany the first column which debouches from the pass. These batteries should deploy as soon as possible after issuing from the gorge and take up advantageous positions in the immediate vicinity. The remainder of the artillery should remain on the near side of the defile and only enter it when the whole engagement is thoroughly decided. During the passage of a river, the bridges are made under cover of the artillery fire, which should be directed on the opposite bank. If it is possible, these guns should be masked by epaulments. On the completion of the bridge, several pieces should accompany the leading columns to protect their deployment. Divisional batteries should follow in the wake of their respective lines. It is a matter of some difficulty to oppose the construction of bridges when the assailant has taken averagely careful uneasiness.

In the majority of cases, an army would be restricted to disputing the passage of the river, and would be guided in doing so by the same rules as have been already laid down for the defence of defiles.

EXTRACT

FROM THE

REPORT OF THE SWEDO-NORWEGIAN ARTILLERY COMMISSION,

UPON VARIOUS SYSTEMS OF MITRAILLEUSES SUBMITTED TO THEM.

Translated from the French by Captain W. H. King Harman, R.A.; Communicated by the Director of Artillery.

THE powerful addition to the fire of infantry by the introduction of the earliest mitrailleuses, the Gatling gun, and the French mitrailleuse, soon drew the public attention to this new arm.

As its name (mitrailleuse, Kartesch-Geschütz) would indicate, it was considered at its first appearance as an improvement upon case shot, the efficacy of which had diminished since the introduction of rifled ordnance. It was soon, however, found that this opinion was erroneous, and that its principal application is circumscribed to positions where it will act as a sure and rapid infantry fire.

Authentic data as to the first employment of this arm (the Gatling gun) in the late war in the United States are wanting.

It was then of so defective a construction that one could hardly expect it to produce any decisive effect. The construction of the French mitrailleuse is equally faulty in many respects, though the cause of the overthrow of the hopes conceived as to its influence on the progress of war is to be sought for rather in the ignorance of the officers and men, by whom it was improperly used, than in the condition of the mitrailleuse itself.

It must always be kept in mind that the equipment of the mitrailleuse in the same manner as the French 4-pr. gun, by which its mobility was greatly reduced, and also the small quantity of ammunition carried in the limber, contributed to diminish the power of this arm, notwithstanding which it was used with considerable effect upon several occasions.

A third mitrailleuse, of which there is some experience as a military arm, is the Bavarian mitrailleuse (Feld'sche-Geschütz), two batteries of which were employed during the last war.

The construction of this mitrailleuse leaves much to be desired—and the effect produced by it can only give an idea of what might be done with one of really good construction. It produced, nevertheless, a marked result at the affair of Coulmiers; one battery of four pieces causing, firstly, a battery of guns to retire when at a distance of from 900 to 1000 yards; and further, repelling three times the attacking columns of the enemy.

The mitrailleuses which are best known besides those above named are the mitrailleur of Montigny and Christophe, and the Gatling gun improved by the Russian General Gorloff (the mitrailleuse Nobel). The first is chiefly a modification of the French mitrailleuse, but it possesses but little advantage over it, while the modifications in the Gatling gun made by General Gorloff are of doubtful value.

The committee wish to give here the more special details of the different sorts of mitrailleuses, of which the Gatling gun has been adopted by England and Turkey, the French mitrailleuse by France alone, that of Montigny and Christophe by Austria, and that of Nobel by Russia. Mitrailleuses have also been the subject of experiment and study in several other European states.

The committee have sought to ascertain what are the requirements of a good mitrailleuse, and would lay them down thus:

The rapidity of fire should reach from 300 to 400 rounds per minute.

The mechanism should not be easily put out of order, even if the rapidity of fire may be required on occasions to exceed the normal standard.

The mechanism, as well as the other parts of the mitrailleuse, should be strong and simple, and as little liable as possible to damage from rust and fouling.

The mitrailleuse should, when with upwards of 4000 rounds in carriage and limber, be capable of draught by two horses.

The piece should be capable of separation from the carriage, and each should be easy of carriage by two men in places inaccessible with horses.

The mitrailleuse should be furnished with apparatus for regulating both horizontal spread and scattering; the latter should be capable of easy adjustment at different angles; finally, two men should be able to perform all the duties required while firing.

The necessary requirements as to precision of fire and distance are treated upon with the ammunition.

In now passing to a succinct description of the mitrailleuses which have been submitted to experiment and study, the committee will indicate at the same time up to what point the different systems fulfil the above requirements.

The Gatling Gun.

This belongs, as is well known, to the description of mitrailleuses in which the barrels revolve, and which are charged successively. Each barrel has its special lock, which accompanies it during its revolution and is capable of motion forwards and backwards, so as to cause the cartridge to enter the barrel; it also serves as a breech when discharged, and then extracts the empty cartridge. In each lock there is a striker with spiral spring and an extractor. The revolution of the system is managed by a crank, adjusted on the right side of the piece.

The Gatling guns of more recent construction present several improvements upon the first system, of which we will point out the following:

The magazines first employed, containing 20 to 25 cartridges, are now

replaced by "drums," which contain 400 cartridges, and thereby greatly increase the rapidity of fire.

Each lock can, without interfering with the rest of the piece, be taken off for repair, or replaced by a new one.

The spring extractor which had not proved certain in operation, is now constructed in such a manner that it cannot fail to extract the empty cartridge.

The gun has been furnished with an automatic scattering arrangement in connection with the crank which moves the system.

On examining how, with these improvements, the Gatling gun fulfils the required conditions, the committee consider, from data supplied to them, that this arm can fire from 300 to 400 rounds per minute; but should this number be exceeded the mechanism is very liable to get out of order,—this is moreover complicated, though it appears strong, and not liable to suffer from rust or fouling.

As far as the committee are aware, no Gatling gun has been mounted so as to be capable of draught by less than four horses, which does not however render it impossible, though the piece itself weighs 330 lbs. for the smallest calibre made. This weight would, under any circumstance, render its conveyance by hand difficult.

The Gatling gun has been furnished with various sorts of scattering apparatus, the last of which, at any rate, fulfilled all the required conditions.

During fire the Gatling gun can be easily handled by two men, one of whom, if not hindered by smoke or other obstructions, could point the piece during the whole of the firing.

The result of what has been said is, that in all essential qualifications the Gatling gun fulfils, or with slight modifications of construction, might be made to fulfil, all the *desiderata* laid down by the committee; but since, as will be seen further on, this system must be considered as inferior in several important points to the two mitrailleuses constructed by Messrs. Winborg and Palmçrantz, the committee do not consider it proper to recommend the adoption of the Gatling gun.

The French Mitrailleuse.

The French mitrailleuse is composed of 25 barrels, fixed in five layers, one above the other, the whole surrounded with a bronze casing, so as to give it the appearance of a field gun.

This casing is prolonged to the rear, where it forms a box, open at the top, in which the loading apparatus is moved backwards and forwards by means of a screw placed in prolongation of the medial line.

The loading apparatus is composed of two parts, namely:—1st, a cartridge plate with 25 holes corresponding to the barrels, and in which the cartridges were placed; and 2ndly, a firing arrangement which contains 25 locks, each composed of a piston and a spiral spring.

In loading, the cartridge plate and the firing arrangement are carried forward by the screw, during which operation the cartridges are partly pushed into the barrels, the pistons being brought up by a closing disc, which also produces the cocking of the piece.

This closing disc has 25 holes, and can, by means of a lever handle fixed to the right side of the piece, be drawn sufficiently to the side to allow the pistons to pass through the corresponding holes, and so to ignite the cartridges. The number of rounds which can habitually be fired with this mitrailleuse is only 100 to 150 per minute, a number far less than that which the committee deems requisite.

If it is added that the service of this arm is laborious, and that the mitrailleuse easily gets out of order, (a fact with regard to which it is only necessary to point out that the cartridges may be fired before the closing of the breech arrangement) the Committee consider that the adoption of this mitrailleuse cannot by any means be recommended.

The Mitrailleuse of Montigny and Christophe.

This mitrailleuse, which in general principles much resembles the French, differs from it in the following particulars.

It is furnished with 37 barrels in place of 25, and the screw, by means of which the loading apparatus is brought into play, is replaced by a lever moving in the same vertical plane as the medial line.

The handle, which gives rotation to the closing disc of the "pistons, or strikers," is also replaced by a long handle which moves on the right side of the piece, parallel to the preceding one.

Light charging discs replace the heavy cartridge plate.

The rapidity of fire of this mitrailleuse has attained on the experimental ground as much as from 350 to 400 rounds per minute; but to obtain this result requires more skill in manipulation than can be expected under ordinary circumstances. While changing the discs one is more than usually liable to accidents which would considerably reduce the aforesaid rate of firing.

The experiments made in England have also shown that this mitrailleuse can only fire from 150 to 200 rounds per minute. The construction, which to a hasty glance appears simple, is nevertheless complicated enough, and the mechanism is composed of a number of parts. It is right to state that, notwithstanding its defects, it is solid and not easily liable to get out of order.

Like the Gatling gun the mitrailleuse of Montigny is considered to require four horses. If in case of necessity this might be obviated for the former, it is, however, little probable that it could for the second. The latter is in itself heavier, and the cartridge boxes, the charging discs, and the pressure quoins or wedges, necessary to the transport of the ammunition, add very considerably to the weight of the carriage and limber.

The space required for the carriage of the loading discs and ammunition contained in them is so great that the carriage and the limber can hardly carry more than 2,000 cartridges.

The service, while firing, of the Montigny requires three men, and is peculiarly arduous upon that one on whom devolves the duty of changing the charging discs, especially when great rapidity of fire is required. Besides this, the movement of the two levers behind the piece renders laying while charging (loading) impossible.

The foregoing will show that in many respects the mitrailleuse of Montigny and Christophe does not fulfil the *desiderata* required by the Committee.

The Bavarian Mitrailleuse.

The Committee have not had favourable opportunities of ascertaining the construction of this mitrailleuse, but they have reason to believe that it is not satisfactory; for instance, it is reported that at the affair at Coulmiers, heretofore mentioned, where four mitrailleuses of this system were in action, all of them got out of order, so much so that after $1\frac{1}{3}$ hours of fighting only three out of their sixteen guns could be fired.

Accordingly, notwithstanding the slight knowledge possessed of this arm, the Committee do not consider it worth further notice.

The Mitrailleuse of Nobel.

This mitrailleuse, identical in all its principal parts with the Gatling gun, and which has been represented as an improvement thereon, has rather lost than gained in efficiency by the greater number of the so-called improvements.

The aim of these seemed to be above all the reduction of weight and an increased rapidity of fire.

The reduction of weight was obtained, on the one hand, by the construction of a lighter carriage, which was detrimental to the accuracy of fire, and by a diminution in height of the breast of the piece, and on the other, by the reduction of the number of barrels to six, of which, besides, the length had similarly been reduced.

The increase of rapidity of fire seems to have been aimed at by the fixing of the crank or handle upon the axis of motion of the system, so as to act directly, but while by this means the rotation was rendered more rapid, and the drums had to be replaced by small magazines containing 25 cartridges each, the result has been such continual changes of magazine as have reduced the rapidity of fire, which it was sought to increase.

In adding that the mitrailleuse has suffered several alterations tending to the better insertion of the cartridges, and the better extraction of the empty cases—alterations upon the efficacy of which the Committee do not wish to offer an opinion—it may be said that the principal differences between this arm and the Gatling gun have been noticed.

The experiments with the mitrailleuse Nobel, which the Committee were instructed by the General-in-Chief (Grand Master) of the Swedish Artillery to carry out, did not take place, in consequence of the ammunition received being, so to speak, unserviceable, having given 60 per cent. of mis-fires, added to which the practice had to be suspended upon three occasions owing to the sticking of the cartridges.

The Committee were further empowered to cease the experiments in consequence of a critical examination of the three mitrailleuses forwarded for experiments having shown the considerable inferiority of the mitrailleuse Nobel compared with the other two.

These inventors have submitted for trial two mitrailleuses, on the construction of which the Committee do not consider it right to give a detailed report, as the invention has not yet been patented.

The earlier in date of these pieces, which we shall now call No. 1, has 10 revolving barrels, which are successively charged from a magazine containing 100 cartridges. The construction is, in an eminent degree, simple and solid, and compares well in these two particulars with the Gatling gun. In the experiments made and of which we shall speak further on, the mitrailleuse No. 1 has proved itself to be perfectly accurate, notwithstanding the rapidity of fire rarely exceeded 300 rounds per minute. If this limit be exceeded, the sticking of a cartridge would lead to delay in the fire, which would, however, not be of long duration.

The Committee do not consider it necessary to remark upon the perfect resistance of this mitrailleuse to damage from rust, as the mechanism is entirely protected, and almost altogether of bronze.

As the mitrailleuse itself only weighs about 200 lbs., and as its magazines are not of such a nature as to contribute in any marked degree to the weight of the ammunition, there is no reason to doubt but that the *desiderata* of the Committee, with respect to lightness, will be fulfilled.

The mitrailleuse is furnished with a lateral pointing-apparatus and a scattering arrangement; the former of the usual construction, the latter, simpler than other similar known arrangements, is besides easy to fix and work.

Under no circumstance are more than two men required for the service of this arm, and should "scattering" not be deemed requisite, one man will suffice.

The mitrailleuse (No. 2) of Winborg and Palmcrantz consists of 10 barrels placed on the same horizontal plane. They are charged simultaneously; one magazine is capable of containing 250 rounds, and the discharge may take place almost simultaneously, like a salvo, or round after round.

All the mechanism is put in motion by a lever, working horizontally on the right side of the piece.

The construction of this mitrailleuse is far simpler and stronger than that of all others known, which at the same time renders it little liable to derangement by rust or fouling.

During the experiments, which occupied eight days, this mitrailleuse was stored in a damp cellar and the mechanism was not cleaned between the firings, and it may be stated that the rust which appeared did not in any way interfere with the working of the mechanism.

As with this mitrailleuse (No. 2) 450 rounds per minute were fired, and as a magazine was emptied with a rapidity amounting to a discharge of 600 rounds per minute, and as the above rapidity in no way interfered with the regular working of the mechanism,—added to which the inventors had it in contemplation to shorten slightly the motion of the lever, the Committee believe that with this arm a rapidity of fire of from 400 to 500 rounds per minute could be attained with certainty.

Although the weight of No. 2 exceeds slightly that of No. 1, and the former arm requires a somewhat heavier and more stable carriage than the latter, to receive the shock of the several rounds at a time, the Committee consider that its transport, with the necessary ammunition, will not require more than two horses, and that the piece, as well as the carriage, might be carried by hand.

The mitrailleuse No. 2 has an ordinary screw for laying laterally, and a scattering apparatus (automatic) of easy fixture and certain to act.

It can be served in all cases by one man.

The Committee now passes to the experiments made on the mitrailleuse of Winborg and Palmcrantz. The following table contains the result of the principal ones; each of these firings was against a target $8' \times 72'$, divided into 72 parts, numbered from the right of the target, and occupied one minute each.

	No. 1 Mitrailleuse—Winborg and Palmcrantz.				No. 2 Mitrailleuse—Winborg and Palmcrantz.			
Range.	No. of Rounds.	Per centage of strikes.	With or without scattering apparatus.	Remarks.	No. of Rounds.	Per centage of strikes.	With or without scattering apparatus.	Remarks.
yds. 195	277	99	Without	Greatest No. of strikes on 4 divisions.	260	95	Without	Greatest No. of strikes on 6 divisions.
195	286	100	With.	63 divisions struck.	270	86	With.	The trail of the carriage was violently forced into the ground, and many bullets passed over the target.
260	343	90	Without	Greatest No. of strikes on 8 divisions.	415	81	Without	Greatest No. of strikes on 9 divisions.
260	315	92	With.	69 divisions struck.	368	86	With.	70 divisions struck.
325	282	78	Without	Greatest No. of strikes on 7 divisions.	350	94	Without	
325	297	77	With.	67 divisions struck.	400	68	With.	66 divisions struck.
650	315	37	Without	Scattered over 27 divisions.	450	40	Without	
650	284	51	With.	63 divisions struck.	372	33	With.	62 divisions struck.

The Committee think it right to make some remarks upon the precision of fire of the mitrailleuse in the foregoing experiments. On the one hand the carriages were not of the construction which, in the opinion of the Committee, they ought to be, and this without doubt contributed much to this precision; on the other, the mitrailleuse was not adjusted beforehand, in consequence of which it was necessary to be content with a provisional adjustment for each distance, which could not give a perfect result, especially at the furthest distance of 650 yards. Besides the experiments, of which note has been taken in the foregoing table, the mitrailleuse No. 2 was subjected to the following two salvos, at a distance of 258 yards, and against the before-mentioned target, in order to test the working of the automatic "scattering" arrangement. The following:—

1st salvo.—6—15—25—33—42—52—58—64—66—67;
2nd „ —7—14—24—32—43—51—58—64—67—68.

Hence we see that the effective shots were slightly greater on the right side of the target, but that apart from this the distribution was regular.

Using the mitrailleuse without magazine, two men, without previous instruction, loading by hand, and a third working the mitrailleuse, about 100 rounds per minute could be fired.

With a view of ascertaining whether a rapidity of fire exceeding the normal rapidity was such as to exert any influence upon the precision of fire, two rounds were fired at a distance of 455 yards against the foregoing target, during which one magazine was emptied in 24″ with 68 per cent., and in 28″ with 65 per cent. of strikes. A somewhat slow fire of one magazine in 50″ gave 80 per cent. of strikes.

Wishing to ascertain the influence that the differences which exist between the Swedish and Norwegian ammunition would exercise upon the employment of the latter in the Swedish mitrailleuse, the Committee ascertained that the ammunition of old pattern might, it is true, be employed, but with a per centage of mis-fires much greater, in consequence of the greater diameter of the case, from which it followed that the stroke of the piston took place at too great a distance from the rim. The new ammunition is, on the other hand, too long to enter the magazines.

During the firing the following inconveniences arose:—With No. 1, a cartridge was once jammed under the cam of the mechanism, which caused an interruption of the fire. This was probably caused by an accidental too rapid motion of the handle. With No. 2, on two occasions an empty case, after extraction, remained in the mechanism, and in two barrels the extractors have several times failed to act.

The first fault, which only caused a very slight cessation of the fire, has been prevented from again occurring, according to the advice of the Committee, by a slight modification, and it did not occur again in the last 1000 rounds. The fault observed in the two extractors must be put down to faulty manufacture. They are the same construction as those of the Gatling, which has shown itself in all respects trustworthy.

In other respects the above-mentioned mitrailleuse presents one essential advantage over all others, viz.: that the non-extraction of an empty cartridge case does not prevent the progress of the fire—only the

cartridge, which should be inserted, is thrown out and the others can be inserted, and fired as before.

Experiment has further shown that by continuing the fire the extraction of an empty case would take place after one or two salvos, and thus everything be put right of itself.

The Committee wish to point out, in conclusion, two qualities in the Swedish mitrailleuse of great importance. The first is, that it can in an instant be rendered useless to the enemy; and the second, that the firing mechanism can be closed so that it is possible at drill to avoid the shocks on the piston which would damage it, and also that the ball ammunition may then be employed without fear.

Founded upon the foregoing the Committee considers itself justified in pronouncing the following judgment.

"The two mitrailleuses constructed by Messrs. Winborg and Palmcrantz are far superior to all the others; and that of these, that with fixed barrels (No. 2) is to be prefered on account of its more simple and more solid construction, its greater rapidity of fire, its accuracy, and the ease with which it is worked."

After the description and judgment passed upon the mitrailleuse submitted to it, the Committee proceeded to consider this arm under varying circumstances, suggested by the General-in-Chief of the Swedish Artillery.

With respect to the question of the employment of mitrailleuses as offensive or defensive weapons, the Committee believe that this arm is chiefly of a defensive nature, which, nevertheless, does not diminish its importance or merits, even in field warfare.

Since the introduction of rifles of great rapidity of fire, it has become less necessary to consider combats in open country than efforts to sieze positions, villages, heights, the edges of forests, &c., the occupation of or the holding of which might often be of the greatest importance. Attacks and counter attacks succeed one another; a position attacked and taken one minute should the next be capable of defence against the determined efforts of the enemy to re-take it.

However, as regards the United Kingdoms, this quality of the mitrailleuse, that of taking part chiefly in defence, should not be considered as a fault, but rather as a reason for its introduction amongst us.

What has been said concerns naturally only the employment of mitrailleuses in the field. In warfare of positions and in fortresses these arms have so great and so evident an importance that opinions cannot differ thereon.

From the ability of the mitrailleuse to produce, in a confined space, an infantry fire of great rapidity and precision, it follows naturally that these pieces should be employed in such places and under such circumstances as, if they did not exist, would require a considerable force of infantry to produce a similar effect. While at the same time it follows from the above that mitrailleuses should not be expected to take the place of artillery; it also follows that they should be formed into batteries,

which opinion is general in those armies into which the mitrailleuse has been adopted.

The Committee consider that a mitrailleuse battery should consist of four pieces.

Doubtless two mitrailleuses (a half battery) could alone strongly reinforce a position, but it would be preferable in a case of importance that a whole battery should be detailed, in order that tenure of a position might not be imperilled by the dismounting of one or two of the mitrailleuses by the fire of the enemy.

On the other hand, circumstances are not likely often to arise when the employment of more than four mitrailleuses would be necessary.

It follows, from the duties which the Committee have thought fit to assign to the mitrailleuses, that the latter should, in the same manner as the artillery, be placed under the command of the divisional Chiefs: that they should be a part of the divisional reserve, and that they should not be attached to brigades or battalions, except when the latter are employed under special circumstances, when the use of mitrailleuses might appear necessary.

In no case, however, should less than two mitrailleuses be detached.

The Committee, who cannot sufficiently insist on the importance of not confounding mitrailleuses with artillery, as much on account of their effect as the proper nature of their employment, believes it to be proper with reference to the organization of this arm, that during peace time they should be attached to batteries or regiments of artillery, and when mobilised to the divisional artillery.

To the second question of the General-in-chief of artillery, viz.: whether the revolving or fixed system of barrels is to be preferred, the Committee does not feel itself in a position to give a direct answer, inasmuch as neither of these systems in itself would be an essential condition of the arm.

With respect to the ammunition which mitrailleuses should be constructed to take, the Committee is convinced that it would be a great advantage if the same ammunition as that carried by the infantry could be also used by the mitrailleuse, and that a departure from this rule should not take place except in case of absolute necessity.

Such a case might be, for example, if the ammunition was too weak to preserve, when employed in the mitrailleuse the accuracy of fire and velocity necessary when employed at the distance which this arm might be employed, as for instance at 1000 yards. In laying down this distance the Committee starts from the supposition that the mitrailleuse should never be employed against artillery when there is more chance of the artillery dismounting the mitrailleuse than there is of the latter preventing the service of the guns.

The Committee would even be disposed to fix this distance at less than 1000 yards did it not consider that the side possessing the mitrailleuse would either have the opportunity of measuring the ranges, or of employing its own artillery at greater distances.

The superiority of the mitrailleuse over infantry, not only in the satisfactory accuracy of fire at distances of from 400 to 1000 yards, which

yet so complete in every respect, and has not been so thoroughly tried that its adoption is advised; and the Committee consider it desirable that this mitrailleuse should be further experimented upon in Sweden—and that with this view, one at least should be purchased and fitted with a carriage and limber to conform to the *desiderata* before mentioned.

(Signed) *Christiania, 30th Nov.*, 1872.

STEPH. MEJDELL,	KLAS. KRENGER,	ROSENBERG,
FRED. F. WESTFELT,	THEOD. FRÖLICH,	O. AQOIST.

The Ranks of the above dignitaries are:

M. STEPH. MEJDELL, Colonel of the Brigade of Norwegian Artillery, and Grand Master of Artillery.

M. KLAS. KRENGER, Lieut.-Colonel of the Artillery of the Swedish Coasting Navy.

M. ROSENBERG, Major in the Norwegian Chasseurs.

M. FRED. WESTFELT, Captain in the Swedish Artillery.

M. THEOD. FRÖLICH, Captain of Brigade in the Norwegian Artillery.

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